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ANALYSIS OF A GENERALIZED DUAL REFLECTOR ANTENNA SYSTEM USING PHYSICAL OPTICS

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ABSTRACT

Reflector antennas are widely used in communication satellite systems because they provide high gain at low cost. Offset-fed single paraboloids and dual reflector offset Cassegrain and Gregorian antennas with multiple focal region feeds provide a simple, blockage-free means of forming multiple, shaped and isolated beams with low sidelobes. Such antennas are applicable to communications satellite frequency reuse systems and earth stations requiring access to several satellites. While the single offset paraboloid has been the most extensively used configuration for the satellite multiple-beam antenna, the trend toward large apertures requiring minimum scanned beam degradation over the field of view 18 degrees for full earth coverage from geostationary orbit may lead to impractically long focal length and large feed arrays. Dual reflector antennas offer packaging advantages and more degrees of design freedom to improve beam scanning and cross-polarization properties. The Cassegrain and Gregorian antennas are the most commonly used dual reflector antennas.

A computer program for calculating the secondary pattern and directivity of a generalized dual reflector antenna system has been developed and implemented at the NASA Lewis Research Center. The theoretical foundation for this program is based on the use of physical optics methodology for describing the induced currents on the sub-reflector and main reflector. The resulting induced currents on the main reflector are integrated to obtain the antenna far-zone electric fields. The computer program is verified with other physical optics programs and with measured antenna patterns. The comparison shows good agreement in far-field sidelobe reproduction and directivity.

INTRODUCTION

The accurate prediction of radiation characteristics for a microwave antenna is essential in designing antenna systems. Antenna radiation characteristics such as beamwidth, gain, aperture efficiency, side-lobe level, and cross polarization are used in analyzing and designing advanced antenna systems. The physical optics-current integration approach (ref. 1) described in this report is one of several methods that can be used for predicting antenna performance characteristics. The method assumes that the complex currents in both reflectors are known. This, in turn, satisfies Maxwell's equations and are used to solve the complex-vector wave equation at any arbitrary observation location. The computation of the induced currents on the main and sub-

reflector are briefly described. A dual reflector configuration (figure 1.) is analyzed, and the results compared with other dual reflector computer programs. A description of the input parameters (user guide) and a copy of the program are included in Appendixes A,B and C.

PHYSICAL OPTICS-CURRENT INTEGRATION APPROACH

DESCRIPTION OF PROBLEM

The geometry of a dual-reflector with a feed at an arbitrary position is shown in Figure 2. Three coordinate systems are shown to define the main reflector, the sub-reflector, and the feed position (or array of feeds). The position and field vectors of these coordinate system can be interrelated by using the Eulerian angles (Figure 3) construction (ref. 2). For instance, the fields of the feed can be expressed in feed coordinates (xf,yf,zf) and then transformed into sub-reflector coordinates (xs,ys,zs) to determine the scattered field from the sub-reflector and then transformed again into main reflector coordinates (xm,ym,zm) to finally obtain the radiated field of the main reflector.

INCIDENT ELECTRIC FIELD ON SUB-REFLECTOR

The radiated electric field from the feed antenna has the asymptotic form given by equation (1):

$$E(\theta, \phi) = \frac{e^{-jkr}}{r} F(\theta, \phi) \quad (1)$$

where $F(\theta, \phi)$ is the element pattern, $k=2\pi/\lambda$ is the wavenumber, and r is the distance from the source (feed) to the sub-reflector point. The vector function in equation (1) can be approximated (ref. 3) by equation (2).

$$F(\theta, \phi) = \theta UE(\theta)(a e^{jp} \cos \phi + b \sin \phi) + \phi UH(\theta)(b \cos \phi + a e^{jp} \sin \phi) \quad (2)$$

where $UE(\theta)$ is the E-plane pattern, $UH(\theta)$ is the H-plane pattern, and a, b , and p are polarization parameters. The various feed polarization parameters are described in the following table:

TABLE I : Polarization Parameters

	a	b	p
Linear x	1	0	0
Linear y	0	1	0
Right-hand circular	0.707	0.7007	+90
Left-hand circular	0.707	0.707	-90

Typically these elements patterns can be approximated by a cosine to a power function, that is,

$$U_E(\theta) = \cos^{q_e}(\theta) \quad (3a)$$

$$U_H(\theta) = \cos^{q_h}(\theta) \quad (3b)$$

If equations (3a) and (3b) are used to represent the element pattern, the power radiated (ref 3.) by this source is given by equation (4).

$$P_{\text{rad}} = \frac{(q_e + q_h + 1)}{60(2q_e + 1)(2q_h + 1)} \quad (4)$$

SURFACE CURRENT APPROXIMATION

The foundations of physical optics (PO), rests on the assumption that the induced current on the reflector surface is given (for a perfect conductor) by

$$\begin{aligned} \mathbf{J} &= 2(\mathbf{n} \times \mathbf{H}^{\text{inc}}) && \text{illuminated region} \\ \mathbf{J} &= 0 && \text{otherwise} \end{aligned}$$

where \mathbf{n} is the unit normal to the surface and \mathbf{H} is the incident magnetic field. This incident field may emanate directly from the source or be scattered from the sub-reflector. Although the PO current is an approximation for the true current on the reflector surface, it nevertheless gives very accurate results for predicting far-field patterns of reflectors.

SCATTERED FIELDS FROM SUB-REFLECTOR

For a given point on the sub-reflector (x_s, y_s, z_s) and the feed located at (x_f, y_f, z_f) the incident fields on the sub-reflector are given

$$E = \frac{e^{-jkr}}{r} F(x_s, y_s, z_s) \quad (5a)$$

where $F(x_s, y_s, z_s)$ is the feed pattern, k the wavenumber and r the distance from the feed to sub-reflector point. The magnetic field incident on the sub-reflector is given by

$$H = (r \times E)/Z_0 \quad (5b)$$

The scattered fields from the sub-reflector are given by (ref.4)

$$H(x_m, y_m, z_m) = jk \iint (J \times r_1) \frac{e^{-jkr_1}}{4\pi r_1} ds \quad (6a)$$

$$E(x_m, y_m, z_m) = -jkZ_0 \iint (J - (J \cdot r_1)r_1) \frac{e^{-jkr_1}}{4\pi r_1} ds \quad (6b)$$

Where J is the induced current on the sub-reflector, r_1 is the distance from any point in the sub-reflector to the observation point (x_m, y_m, z_m) . r_1 is a unit vector in the direction from any point in the sub-reflector to any observation point on the main reflector (x_m, y_m, z_m) .

MAIN REFLECTOR FAR-FIELDS

The resulting induced currents produced by the sub-reflector scattering the main reflector are integrated to obtain the far-zone electric fields.

$$E(\theta, \phi) = -jkZ_0 e^{-jkr} \iint (J - (J \cdot R)R) \frac{e^{jkr}}{4\pi R} ds \quad (7a)$$

$$H(\theta, \phi) = (R \times E)/Z_0 \quad (7b)$$

Where J is the induced current in the main reflector, R is a unit vector from any point in the main reflector to the far-field observation point. r is the distance from the origin of the main reflector coordinate system to any point in the main reflector.

This method of calculating secondary pattern is accurate in cases where the antenna diameter is of the order greater than 50 to 100 wavelength. If the antenna diameter is of the order less than 50 wavelength, the accuracy is reduced, specifically in the sidelobe region. The reflector configuration described in figure 1 was analyzed by using various methods and computer codes. The calculated E- and H- plane far-field antenna pattern and directivities are shown in figures 4a and 4b respectively. The directivity and the far-field pattern are in a very good agreement among computer programs. The computer program given in appendix C was used to analyze the configuration.

DIRECTIVITY

The far zone electric field is usually divided into two orthogonal polarizations. Following Ludwig's definition 3 (ref. 4) the following unitary polarization vectors are introduced

$$R = \theta (a e^{jp} \cos \phi + b \sin \phi) + \phi (-a e^{jp} \sin \phi + b \cos \phi) \quad (8a)$$

$$C = \theta (a e^{jp} \sin \phi - b \cos \phi) + \phi (a e^{jp} \cos \phi + b \sin \phi) \quad (8b)$$

if the secondary pattern can be expressed as

$$E = \frac{e^{-jkr}}{r} (E_\theta(\theta, \phi) + E_\phi(\theta, \phi)) \quad (9)$$

The reference-polarization expression is

$$E_{\text{ref}} = E \cdot (R^*)^* \quad (10a)$$

and the cross-polarization expression is

$$C_{\text{cross}} = E \cdot (C^*)^* \quad (10b)$$

The directivity for the reference polarization is defined by

$$DR(\theta, \phi) = \frac{4\pi (E_{\text{ref}} \cdot E_{\text{ref}}^*) / Z_0}{P_{\text{rad}}} \quad (11a)$$

similarly the directivity for the cross polarization is defined by

$$DC(\theta, \phi) = \frac{4\pi (E_{\text{cross}} \cdot E_{\text{cross}}^*) / Z_0}{P_{\text{rad}}} \quad (12b)$$

CONCLUDING REMARKS

A computer program using physical optics-current integration method, has been developed for calculating the far-field antenna pattern of dual reflector antennas illuminated by a feed with arbitrary polarization. The program utilizes a 3th order polynomial spline or nth order polynomial interpolation algorithms for cases in which the reflectors are numerically specified. The results for the far-field sidelobes and directivity are in good agreement with those obtained by other well-known techniques.

The computer program based on physical optics-current integration techniques is one of the main system engineering tools used at NASA Lewis Research Center for analyzing advanced antenna systems.

APPENDIX A

IDEAL REFLECTOR CONFIGURATIONS

Offset dual-reflectors are carved-out of portions of surfaces of revolutions (paraboloids, ellipsoids, hyperboloids, etc.) resulting from the intersection with cylinders or cones. The cylinders have their axes parallel to the axes of the parent reflector surfaces and the cones have their tips at one of the foci of the reflectors. In this appendix the geometrical characteristic of offset conic sections are presented.

The following are the analytical equations describing parabolic, hyperbolic and elliptical surfaces of revolution all are shown in main reflector coordinate system.

A: Parabolic reflector : The geometry associated with a parabolic reflector is shown in figure A-1

Parameters : F focal length

$$\text{Equation : } z = \frac{x^2 + y^2}{4F}$$

B: Hyperbolic Sub-reflector : The geometry associated with a hyperbolic sub-reflector is shown in figure A-2.

Parameters : z_0 offset distance
a vertex distance

$$b = \sqrt{c^2 - a^2}$$

2c foci distance

$$\text{Equation : } z = z_0 + a \sqrt{1 + \frac{x^2 + y^2}{b^2}}$$

C: Elliptical sub-reflector : The geometry associated with an elliptical sub-reflector is shown in figure A-3.

Parameters : z_0 offset distance
 a vertex distance

$$b = \sqrt{a^2 - c^2}$$

$2c$ foci distance

Equation : $z = z_0 + a \sqrt{1 - \frac{x^2 + y^2}{b^2}}$

APPENDIX B

PROGRAM INPUT USER GUIDE

A computer program was designed to calculate the antenna performance characteristics. The method of analysis is physical optics. The program runs in an IBM370 using VM operating system. All the inputs are put into the program DRSG FORTRAN and are describe as follows:

FFREQ	frequency GHz
QQ	feed pattern exponent
DMX,DMY	x and y length in wavelength main reflector rectangle
DSX,DSY	x and y length in wavelength sub-reflector rectangle
MAXMX,MAXSY	number of points in the x and y direction
xm0,ym0,zm0	lower left corner of main reflector rectangle
xs0,ys0,zs0	lower left corner of sub-reflector rectangle
xf,yf,zf	feed location in wavelength
xr,yr,zr	feed boresight point on sub-reflector
rtemp1 (sub)	parameter a in wavelength
rtemp2	parameter $b=\sqrt{a^2-c^2}$
rtemp6	offset distance in wavelength
fradsq	radius square of cylinder sub-reflector
FCENX,FCENY	center of sub-reflector cylinder
radsq	radius of cylinder of main reflector
CNTRX,CNTRY	center of cylinder of main reflector
rtemp1 (main)	1/4F, F is focal length in wavelength

APPENDIX C COMPUTER PROGRAM

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PROGRAM DRSG
*****
* NASA LEWIS RESEARCH CENTER
* AUTHOR : R. ACOSTA AND A. LAGIN IBM 370 VM VERSION
* DATE : 7/14/91
* PURPOSE : TO SIMULATE GENERALIZED SURFACES OF REVOLUTION
* FOR THE GENERALIZED DUAL REFLECTOR ANALYSIS PROGRAM
*****
** COMPILE CONSTANTS
*****
REAL C
PARAMETER (C = 2.99792458E+08 )
REAL PI
PARAMETER (PI = 3.141592653589793238)
REAL ETA
PARAMETER (ETA = 4.0*PI*C*(1.E-7) )
*****
*****INPUT : FREQUENCY (HZ)*****
*****
REAL FREQQ
PARAMETER (FREQQ = 19.45*(1.E+9) )
*****
REAL LAMBDA
PARAMETER (LAMBDA =(C/FREQQ)*1.000 )
REAL LAMBSQ
PARAMETER (LAMBSQ = LAMBDA*LAMBDA )
*****
*****INPUT : QQ : FEED PATTERN EXPONENT*****
*****
REAL QQ
PARAMETER (QQ = 62.00 )
*****
INTEGER MXYZ
PARAMETER (MXYZ = 4 )
INTEGER DXYZ
PARAMETER (DXYZ = 3 )
INTEGER LNRY
PARAMETER (LNRY = 1 )
INTEGER MDTX
PARAMETER (MDTX = 10 )
*****
** INTRINSIC FUNCTIONS
*****
INTRINSIC SQRT
INTRINSIC INT
INTRINSIC NINT
*****
** EXTERNAL SUBROUTINES
*****
EXTERNAL SUBMAI
*****
REAL DATARY(MDTX)
REAL DMX,DMY
REAL INCMX,INCMY
REAL DSX,DSY
REAL INCSX,INCSY
REAL FREQ
REAL Q
*****
** EQUIVALENCE

```

DRS00010
 DRS00020
 DRS00030
 DRS00040
 DRS00050
 DRS00060
 DRS00070
 DRS00080
 DRS00090
 DRS00100
 DRS00110
 DRS00120
 DRS00130
 DRS00140
 DRS00150
 DRS00160
 DRS00170
 DRS00180
 DRS00190
 DRS00200
 DRS00210
 DRS00220
 DRS00230
 DRS00240
 DRS00250
 DRS00260
 DRS00270
 DRS00280
 DRS00290
 DRS00300
 DRS00310
 DRS00320
 DRS00330
 DRS00340
 DRS00350
 DRS00360
 DRS00370
 DRS00380
 DRS00390
 DRS00400
 DRS00410
 DRS00420
 DRS00430
 DRS00440
 DRS00450
 DRS00460
 DRS00470
 DRS00480
 DRS00490
 DRS00500
 DRS00510
 DRS00520
 DRS00530
 DRS00540
 DRS00550
 DRS00560
 DRS00570
 DRS00580
 DRS00590
 DRS00600

```

*****DRS00610
EQUIVALENCE (DATARY( 1),DMX ) DRS00620
EQUIVALENCE (DATARY( 2),DMY ) DRS00630
EQUIVALENCE (DATARY( 3),INCMX) DRS00640
EQUIVALENCE (DATARY( 4),INCMY) DRS00650
EQUIVALENCE (DATARY( 5),DSX ) DRS00660
EQUIVALENCE (DATARY( 6),DSY ) DRS00670
EQUIVALENCE (DATARY( 7),INCSX) DRS00680
EQUIVALENCE (DATARY( 8),INCSY) DRS00690
EQUIVALENCE (DATARY( 9),FREQ ) DRS00700
EQUIVALENCE (DATARY(10),Q ) DRS00710
INTEGER MAXMX,MAXMY DRS00720
INTEGER MAXSX,MAXSY DRS00730
*****DRS00740
** INITIAL CALCUALTIONS DRS00750
*****DRS00760
*INPUT: LENGTH OF MAIN REF. RECTANGLE GRID DRS00770
*****DRS00780
DMX = (220.0 *LAMBDA) DRS00790
DMY = (220.0 *LAMBDA) DRS00800
*****DRS00810
*****INPUT : NUMBER POINTS IN X AND Y MAIN REF. RECTANGLE GRID***** DRS00820
*****DRS00830
MAXMX = 101 DRS00840
MAXMY = 101 DRS00850
*****DRS00860
INCMX = DMX/(REAL((MAXMX-1))) DRS00870
INCMY = DMY/(REAL((MAXMY-1))) DRS00880
*****DRS00890
*****INPUT : LENGHT OF SUB REF. RECTANGLE GRID ***** DRS00900
*****DRS00910
DSX = ( 82.50 *LAMBDA) DRS00920
DSY = ( 82.50 *LAMBDA) DRS00930
*****DRS00940
*****INPUT : NUMBER OF POINTS IN X AND Y IN THE SUB REFLECTOR GRID* DRS00950
*****DRS00960
MAXSX = 61 DRS00970
MAXSY = 61 DRS00980
*****DRS00990
INCSX = (DSX/REAL(MAXSX-1)) DRS01000
INCSY = (DSY/REAL(MAXSY-1)) DRS01010
*****DRS01020
FREQ = FREQQ DRS01030
Q = QQ DRS01040
CALL SUBMAI(MAXMY,MAXMX,MAXSY,MAXSX,MDTX,DATARY) DRS01050
END DRS01060
*****DRS01070
*****SUBROUTINE SUBMAI***** DRS01080
*****DRS01090
SUBROUTINE SUBMAI(PMXMY,PMXMX,PMXSY,PMXSX,PDTX,DTAARX) DRS01100
INTEGER PMXMY DRS01110
INTEGER PMXMX DRS01120
INTEGER PMXSY DRS01130
INTEGER PMXSX DRS01140
INTEGER PDTX DRS01150
REAL DTAARX(PDTX) DRS01160
REAL C DRS01170
PARAMETER (C = 2.99792458E+08 ) DRS01180
REAL PI DRS01190
PARAMETER (PI = 3.141592653589793238) DRS01200

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REAL	ETA				DRS01210
PARAMETER	(ETA	= 4.0*PI*C*(1.E-7))		DRS01220
*****					DRS01230
*****INPUT : FREQUENCY*****					DRS01240
*****					DRS01250
REAL	FREQQ				DRS01260
PARAMETER	(FREQQ	= 19.45*(1.E+9)	)		DRS01270
*****					DRS01280
REAL	LAMBDA				DRS01290
PARAMETER	(LAMBDA	=(C/FREQQ)*1.000	)		DRS01300
REAL	LAMBSQ				DRS01310
PARAMETER	(LAMBSQ	= LAMBDA*LAMBDA	)		DRS01320
*****					DRS01330
*****INPUT : QQ:EXPONED EXPONENT*****					DRS01340
*****					DRS01350
REAL	QQ				DRS01360
PARAMETER	(QQ	= 62.000	)		DRS01370
*****					DRS01380
INTEGER	MXYZ				DRS01390
PARAMETER	(MXYZ	= 4	)		DRS01400
INTEGER	DXYZ				DRS01410
PARAMETER	(DXYZ	= 3	)		DRS01420
INTEGER	LNRY				DRS01430
PARAMETER	(LNRY	= 1	)		DRS01440
INTEGER	VDTX				DRS01450
PARAMETER	(VDTX	= 4	)		DRS01460
INTEGER	MDTX				DRS01470
PARAMETER	(MDTX	= 10	)		DRS01480
INTEGER	IDXZ				DRS01490
INTEGER	IDXZX				DRS01500
INTEGER	IDXZY				DRS01510
INTEGER	IDXMSK				DRS01520
INTEGER	MXMX, MXMY, TMXMX, TMXMY				DRS01530
INTEGER	MXSX, MXSY, TMXSX, TMXSY				DRS01540
PARAMETER	(IDXZ	= 1	)		DRS01550
PARAMETER	(IDXZX	= 2	)		DRS01560
PARAMETER	(IDXZY	= 3	)		DRS01570
PARAMETER	(IDXMSK	= 4	)		DRS01580
*****					DRS01590
*****INPUT : NUMBER OF POINTS (-1) MAIN AND SUB REFLECTOR GRIDS***					DRS01600
*****					DRS01610
PARAMETER	(MXMX	= 101	)		DRS01620
PARAMETER	(MXMY	= 101	)		DRS01630
PARAMETER	(MXSX	= 61	)		DRS01640
PARAMETER	(MXSY	= 61	)		DRS01650
*****					DRS01660
PARAMETER	(TMXMX	= MXMX + 1	)		DRS01670
PARAMETER	(TMXMY	= MXMY + 1	)		DRS01680
PARAMETER	(TMXSX	= MXSX + 1	)		DRS01690
PARAMETER	(TMXSY	= MXSY + 1	)		DRS01700
*****					DRS01710
*****					DRS01720
REAL	MAIARY	(4, TMXMY, TMXMX)			DRS01730
REAL	SUBARY	(4, TMXSY, TMXSX)			DRS01740
REAL	XYZARY	(DXYZ, MXYZ)			DRS01750
REAL	MRXYZO	(DXYZ), XMO, YMO, ZMO			DRS01760
REAL	SRXYZO	(DXYZ), XSO, YSO, ZSO			DRS01770
REAL	FEDXYZ	(DXYZ), XF, YF, ZF			DRS01780
REAL	REFXYZ	(DXYZ), XR, YR, ZR			DRS01790
REAL	DMX, DMY				DRS01800

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REAL      INCMX, INCMY                      DRS01810
REAL      DSX,DSY                          DRS01820
REAL      INCSX, INCSY                     DRS01830
REAL      FREQ                             DRS01840
REAL      Q                               DRS01850
***** DRS01860
** EQUIVALENCE                             DRS01870
***** DRS01880
EQUIVALENCE (XYZARY(1,1),MRXYZO(1))       DRS01890
EQUIVALENCE (XYZARY(1,2),SRXYZO(1))       DRS01900
EQUIVALENCE (XYZARY(1,3),FEDXYZ(1))       DRS01910
EQUIVALENCE (XYZARY(1,4),REFXYZ(1))       DRS01920
EQUIVALENCE (MRXYZO(1),XMO )              DRS01930
EQUIVALENCE (MRXYZO(2),YMO )              DRS01940
EQUIVALENCE (MRXYZO(3),ZMO )              DRS01950
EQUIVALENCE (SRXYZO(1),XSO )              DRS01960
EQUIVALENCE (SRXYZO(2),YSO )              DRS01970
EQUIVALENCE (SRXYZO(3),ZSO )              DRS01980
EQUIVALENCE (FEDXYZ(1),XF )               DRS01990
EQUIVALENCE (FEDXYZ(2),YF )               DRS02000
EQUIVALENCE (FEDXYZ(3),ZF )               DRS02010
EQUIVALENCE (REFXYZ(1),XR )               DRS02020
EQUIVALENCE (REFXYZ(2),YR )               DRS02030
EQUIVALENCE (REFXYZ(3),ZR )               DRS02040
***** DRS02050
***** DRS02060
REAL      MAIXYZ(3),XM, YM, ZM             DRS02070
REAL      SUBXYZ(3),XS, YS, ZS             DRS02080
REAL      GENXYZ(3),XI, YJ, ZIJ            DRS02090
REAL      RADSQ,XSQ                        DRS02100
REAL      CNTRX                           DRS02110
REAL      CNTRY                            DRS02120
REAL      RTEMPO                           DRS02130
REAL      RTEMP1                           DRS02140
REAL      RTEMP2                           DRS02150
REAL      RTEMP3                           DRS02160
REAL      RTEMP4                           DRS02170
REAL      RTEMP5                           DRS02180
REAL      RTEMP6                           DRS02190
INTEGER   I,J,V,W                         DRS02200
***** DRS02210
** EQUIVALENCE                             DRS02220
***** DRS02230
EQUIVALENCE (SUBXYZ(1),XS )               DRS02240
EQUIVALENCE (SUBXYZ(2),YS )               DRS02250
EQUIVALENCE (SUBXYZ(3),ZS )               DRS02260
EQUIVALENCE (MAIXYZ(1),XM )               DRS02270
EQUIVALENCE (MAIXYZ(2),YM )               DRS02280
EQUIVALENCE (MAIXYZ(3),ZM )               DRS02290
EQUIVALENCE (GENXYZ(1),XI )               DRS02300
EQUIVALENCE (GENXYZ(2),YJ )               DRS02310
EQUIVALENCE (GENXYZ(3),ZIJ )              DRS02320
***** DRS02330
** Initialize Arrays                       DRS02340
** MAIFIL <== MAIARY()                    DRS02350
** SUBFIL <== SUBARY()                     DRS02360
** XYZFIL <== XYZARY() <== MRXYZO(),SRXYZO(),FEDXYZ(),REFXYZ() DRS02370
** DTAFIL <== DTAARX() <== DMX,DMY,INCMX,INCMY,DSX,DSY,INCSX,INCSY,FREQ, DRS02380
***** DRS02390
DO 20200 I = 1,TMXMX,1                    DRS02400

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DO 20100 J = 1, TMXMY, 1
DO 20000 W = 1, 4, 1
MAIARY(W, J, I) = 0.
20000 CONTINUE
20100 CONTINUE
20200 CONTINUE
DO 20500 I = 1, TMXSX, 1
DO 20400 J = 1, TMXSY, 1
DO 20300 W = 1, 4, 1
SUBARY(W, J, I) = 0.
20300 CONTINUE
20400 CONTINUE
20500 CONTINUE
*****
*****INPUT : LOWER LEFT CORNER OF MAIN REF GRID*****
*****
XMO = ( -110.00000000 *LAMBDA)
YMO = ( 79.65000000 *LAMBDA)
ZMO = ( 1.000000000 *LAMBDA)
*****
*****INPUT: LOWER LEFT CORNER OF SUB REFLECTOR GRID*****
*****
XSO = ( -41.25000000 *LAMBDA)
YSO = ( 000.00000000 *LAMBDA)
ZSO = ( 1.000000000 *LAMBDA)
*****
*****INPUT : FEED COORDINATES*****
*****
*****BORSIGHT BEAM FEED COORDINATES:
XF = ( 0.000000000 *LAMBDA)
* YF = ( 0.000000000 *LAMBDA)
* ZF = ( 103.93560000 *LAMBDA)
*****CLEVELAND BEAM FEED COORDINATES:
YF = ( 5.629 * LAMBDA)
ZF = ( 101.067 * LAMBDA)
*****MIAMI BEAM FEED COORDINATES:
* XF = ( -16.4 * LAMBDA)
* YF = ( 9.62287 * LAMBDA)
* ZF = ( 99.0325 * LAMBDA)
*****LOS ANGELES BEAM FEED COORDINATES:
* XF = (-7.996 *LAMBDA)
* YF = (-30.52 *LAMBDA)
* ZF = ( 119.49 *LAMBDA)
*****SEATTLE BEAM FEED COORDINATES:
* XF = ( 3.4579 *LAMBDA)
* YF = (-30.2 *LAMBDA)
* ZF = (119.32 *LAMBDA)
*****
*****INPUT : REFERENCE RAY LOCATION COORDINATES *****
*****
XR = ( 0.000000000 *LAMBDA)
YR = ( 41.25000000 *LAMBDA)
* YR = ( 30.00000000 *LAMBDA)
Y = YR*39.36
ZR = ( 11.5*SQRT(1+(XR**2+Y**2)/1058)+97.5)
ZR=ZR/39.36
*****
DMX = DTAARX( 1)
DMY = DTAARX( 2)
INCMX = DTAARX( 3)

```

DRS02410
 DRS02420
 DRS02430
 DRS02440
 DRS02450
 DRS02460
 DRS02470
 DRS02480
 DRS02490
 DRS02500
 DRS02510
 DRS02520
 DRS02530
 DRS02540
 DRS02550
 DRS02560
 DRS02570
 DRS02580
 DRS02590
 DRS02600
 DRS02610
 DRS02620
 DRS02630
 DRS02640
 DRS02650
 DRS02660
 DRS02670
 DRS02680
 DRS02690
 DRS02700
 DRS02710
 DRS02720
 DRS02730
 DRS02740
 DRS02750
 DRS02760
 DRS02770
 DRS02780
 DRS02790
 DRS02800
 DRS02810

INCMY	= DTAARX(4)	DRS02820
DSX	= DTAARX(5)	DRS02830
DSY	= DTAARX(6)	DRS02840
INCSX	= DTAARX(7)	DRS02850
INCSY	= DTAARX(8)	DRS02860
FREQ	= DTAARX(9)	DRS02870
Q	= DTAARX(10)	DRS02880
*****TO GENERATE THE INPUT ARRAYS*****		DRS02890
*****		DRS02900
DO 10 I=1,10		DRS02910
WRITE(15,805)DTAARX(I)		DRS02920
805 FORMAT(5X,E15.8)		DRS02930
10 CONTINUE		DRS02940
DO 11 I=1,4		DRS02950
DO 12 J=1,3		DRS02960
WRITE(16,806)XYZARY(J,I)		DRS02970
806 FORMAT(5X,E15.8)		DRS02980
12 CONTINUE		DRS02990
11 CONTINUE		DRS03000
*****		DRS03010
** Calculate Z, Zx, Zy, Usage for SubReflector.		DRS03020
****Z = SUBARY(IDXZ,... SURFACE Z		DRS03030
****DX= SUBARY(IDXZX... DERIVATIVE WITH RESP. TO X		DRS03040
****DY= SUBARY(IDXZY... DERIVATIVE WITH RESP. TO Y		DRS03050
*****		DRS03060
RTEMP0 = (LAMBDA)		DRS03070
*****		DRS03080
*****INPUT : A :PARAMETER OF SURFACE OF REVOLUTION*****		DRS03090
*****		DRS03100
RTEMP1 = (18.97*RTEMP0)		DRS03110
*****		DRS03120
*****INPUT : 1/B**2 PARAMETER OF SURFACE OF REVOLUTION*****		DRS03130
*****		DRS03140
RTEMP2 = (1./(.6829))		DRS03150
*****		DRS03160
*****INPUT : Z0 OFFSET OF THE CENTER OF THE SURFACE OFF REV.**		DRS03170
*****		DRS03180
RTEMP6 = 160.85*RTEMP0		DRS03190
*****		DRS03200
****INPUT: RADIUS OF CYLINDER OF SUB-REFLECTOR*****		DRS03210
*****		DRS03220
FRADSQ=(19.0*RTEMP0)**2		DRS03230
*****		DRS03240
****INPUT: CENTER OF COORDINATES OF CYLINDER*****		DRS03250
*****		DRS03260
FCENX=0.0		DRS03270
FCENY=31.8*RTEMP0		DRS03280
*****		DRS03290
XS = XS0 - INCSX		DRS03300
DO 20700 I = 1, TMXSX, 1		DRS03310
XS = XS + INCSX		DRS03320
XSQ = XS*XS		DRS03330
YS = YS0 - INCSY		DRS03340
DO 20600 J = 1, TMXSY, 1		DRS03350
YS = YS + INCSY		DRS03360
FTEMP=(XS-FCENX)**2+(YS-FCENY)**2		DRS03370
* IF(FTEMP.GT.FRADSQ) GO TO 309		DRS03380
RTEMP3 = ((XSQ) + (YS*YS))		DRS03390
RTEMP4 = (SQRT(1+ RTEMP3*RTEMP2))		DRS03400
		DRS03410

```

RTEMP5 = ((RTEMP1*RTEMP2)/RTEMP4)
*
* +=====DRS03440
* | SubReflector: HyperbolaDRS03450
* |DRS03460
* | +-----DRS03470
* | / 2 2DRS03480
* | / 2 2DRS03490
* | Z = 18.97*LAMBDA X / 1 + (X + Y) +160.85*LAMBDAADR03520
* | / -----DRS03530
* | \ / ( 0.6829 )DRS03540
* |DRS03550
* |DRS03560
* |DRS03570
* |DRS03580
* |DRS03590
* |DRS03600
* | +-----DRS03610
* | / 2 2DRS03620
* | X / X + YDRS03630
* | ZX = 18.97 (-----) / / 1+(-----)DRS03640
* | 150.XLAMBDA \ / 0.6829DRS03650
* |DRS03660
* | +-----DRS03670
* | / 2 2DRS03680
* | Y / X + YDRS03690
* | ZY = 18.97 (-----) / / 1+(-----)DRS03700
* | 150.XLAMBDA \ / 0.6829DRS03710
* |DRS03720
* | +-----DRS03730
* | / 2 2DRS03740
* | Y / X + YDRS03750
* | ZY = 18.97 (-----) / / 1+(-----)DRS03760
* | 150.XLAMBDA \ / 0.6829DRS03770
* |DRS03780
* |DRS03790
* |DRS03800
* |DRS03810
* |DRS03820
* |DRS03830
* |DRS03840
* |DRS03850
* +=====DRS03860
* |DRS03870
* |DRS03880
* |-----DRS03890
* | SUBARY(IDXZ ,J,I) = ((RTEMP6)+RTEMP1*RTEMP4)DRS03900
* | SUBARY(IDXZX ,J,I) = (XS*RTEMP5 )DRS03910
* | SUBARY(IDXZY ,J,I) = (YS*RTEMP5 )DRS03920
* | SUBARY(IDXMSK,J,I) = 1.DRS03930
* |-----DRS03940
20520 FORMAT (5X,4(E15.8,2X))DRS03950
309 WRITE(17,20520) SUBARY(IDXZ ,J,I),SUBARY(IDXZX ,J,I),DRS03960
1 SUBARY(IDXZY ,J,I),SUBARY(IDXMSK,J,I)DRS03970
20600 CONTINUEDRS03980
20700 CONTINUEDRS03990
*****DRS04000
*****DRS04010

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```

** Calculate Z, Zx, Zy, Usage for MainReflector.
****Z = MAIARY(IDXZ,... SURFACE FUNCTION
****Z = MAIARY(IDXZX,... DERIVATIVE WITH RESP. X
****Z = MAIARY(IDXZY,... DERIVATIVE WITH RESP. Y
*****
RTEMPO=LAMBDA
XM = XMO - INCMX
*****
*****INPUT: RADIUS OF CYLINDER MAIN REFLECTOR*****
*****
* RADSQ = (107.2*RTEMPO)**2
RADSQ = (108.2*RTEMPO)**2
*****
****INPUT: CENTER OF COORDINATES OF CYLINDER*****
*****
CNTRX = 0.0
CNTRY = 189.7*RTEMPO
*****
*****INPUT : 1/4F PARAMETER FOCAL LENGTH*****
*****
RTEMP1 = (1./(870.00*RTEMPO))
RTEMP2 = 2*RTEMP1
DO 20900 I = 1, TMXMX, 1
XM = XM + INCMX
XSQ = XM*XM
YM = YMO - INCMY
DO 20800 J = 1, TMXMY, 1
YM=YM+INCMY
RTEMP4 = (((XM-CNTRX)*(XM-CNTRX))+((YM-CNTRY)*(YM-CNTRY)))
IF (RTEMP4 .GT. RADSQ) GO TO 450
*
*
* | MaiReflector: Parabola
*
* |
* |
* | 2 2
* | ( X + Y )
* |
* | Z = -----
* | (870. X LAMBDA)
* |
* |
* | X
* |
* | Zx = -----
* | (435. X LAMBDA)
* |
* |
* | Y
* |
* | Zy = -----
* | (435. X LAMBDA)
*

```

DRS04020
 DRS04030
 DRS04040
 DRS04050
 DRS04060
 DRS04070
 DRS04080
 DRS04090
 DRS04100
 DRS04110
 DRS04120
 DRS04130
 DRS04140
 DRS04150
 DRS04160
 DRS04170
 DRS04180
 DRS04190
 DRS04200
 DRS04210
 DRS04220
 DRS04230
 DRS04240
 DRS04250
 DRS04260
 DRS04270
 DRS04280
 DRS04290
 DRS04300
 DRS04310
 DRS04320
 DRS04330
 DRS04340
 DRS04350
 DRS04360
 DRS04370
 DRS04380
 DRS04390
 DRS04400
 DRS04410
 DRS04420
 DRS04430
 DRS04440
 DRS04450
 DRS04460
 DRS04470
 DRS04480
 DRS04490
 DRS04500
 DRS04510
 DRS04520
 DRS04530
 DRS04540
 DRS04550
 DRS04560
 DRS04570
 DRS04580
 DRS04590
 DRS04600

*	|	DRS04610
*		DRS04620
*	+=====	DRS04630
*		DRS04640
	MAIARY(IDXZ ,J,I) = ((XM*XM)+(YM*YM))*RTEMP1	DRS04650
	MAIARY(IDXZX ,J,I) = (XM*RTEMP2)	DRS04660
	MAIARY(IDXZY,J,I) = (YM*RTEMP2)	DRS04670
	MAIARY(IDXMSK,J,I) = 1.	DRS04680
450	WRITE(18,20520) MAIARY(IDXZ ,J,I),MAIARY(IDXZX ,J,I)	DRS04690
1	,MAIARY(IDXZY ,J,I),MAIARY(IDXMSK ,J,I)	DRS04700
20800	CONTINUE	DRS04710
20900	CONTINUE	DRS04720
	END	DRS04730
		DRS04740

PROGRAM DUALREF	DUA00010
*****	DUA00020
* AUTHOR : R. ACOSTA AND A. LAGIN VM VERSION	DUA00030
* DATE : 7/15/91	DUA00040
* PURPOSE : TO COMPUTE FAR FIELD CO-POL AND CROSS POL OF A	DUA00050
* GENERALIZED DUAL REFLECTOR SYSTEM	DUA00060
* GENERALIZED DUAL REFLECTOR ANALYSIS PROGRAM	DUA00070
*****	DUA00080
** COMPILE CONSTANTS	DUA00090
*****	DUA00100
REAL C	DUA00110
PARAMETER (C = 2.99792458E+08)	DUA00120
REAL PI	DUA00130
PARAMETER (PI = 3.141592653589793238)	DUA00140
REAL ETA	DUA00150
PARAMETER (ETA = 4.0*PI*C*(1.E-7))	DUA00160
REAL R2DEG	DUA00170
PARAMETER (R2DEG = 180./PI)	DUA00180
REAL D2RAD	DUA00190
PARAMETER (D2RAD = PI/180.)	DUA00200
INTEGER IDXZ	DUA00210
INTEGER IDXZX	DUA00220
INTEGER IDXZY	DUA00230
INTEGER IDXMSK	DUA00240
INTEGER IDXVCX	DUA00250
INTEGER IDXVCY	DUA00260
INTEGER IDXVCZ	DUA00270
INTEGER IDXRMJ	DUA00280
INTEGER IDXIMJ	DUA00290
INTEGER IDXUNM	DUA00300
INTEGER IDXJVX	DUA00310
INTEGER IDXNRM	DUA00320
INTEGER IDXDTX	DUA00330
INTEGER IDXMMN	DUA00340
INTEGER IDXMSI	DUA00350
INTEGER IDXAOT	DUA00360
INTEGER IDXPWR	DUA00370
INTEGER IDXADB	DUA00380
INTEGER IDXRDB	DUA00390
INTEGER MXMX, MXMY, TMXMX, TMXMY	DUA00400
INTEGER MXSX, MXSY, TMXSX, TMXSY	DUA00410
INTEGER MXTHE, MXPHI	DUA00420
INTEGER MXYZ	DUA00430
INTEGER DXYZ	DUA00440
INTEGER LNRY	DUA00450
INTEGER VDTX	DUA00460
INTEGER NDTX	DUA00470
INTEGER MDTX	DUA00480
INTEGER KDTX	DUA00490
PARAMETER (IDXZ = 1)	DUA00500
PARAMETER (IDXZX = 2)	DUA00510
PARAMETER (IDXZY = 3)	DUA00520
PARAMETER (IDXMSK = 4)	DUA00530
PARAMETER (IDXVCX = 1)	DUA00540
PARAMETER (IDXVCY = 2)	DUA00550
PARAMETER (IDXVCZ = 3)	DUA00560
PARAMETER (IDXRMJ = 1)	DUA00570
PARAMETER (IDXIMJ = 2)	DUA00580
PARAMETER (IDXUNM = 3)	DUA00590
PARAMETER (IDXJVX = 1)	DUA00600

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PARAMETER (IDXNRM = 2 ) DUA00610
PARAMETER (IDXDTX = 3 ) DUA00620
PARAMETER (IDXNMN = 1 ) DUA00630
PARAMETER (IDXMSI = 2 ) DUA00640
PARAMETER (IDXAOT = 3 ) DUA00650
PARAMETER (IDXPWR = 1 ) DUA00660
PARAMETER (IDXADB = 2 ) DUA00670
PARAMETER (IDXRDB = 3 ) DUA00680
***** DUA00690
*****INPUT : NUMBER OF POINTS IN X AND Y MAIN REF. GRID.***** DUA00700
***** DUA00710
PARAMETER (MXMX = 101 ) DUA00720
PARAMETER (MXMY = 101 ) DUA00730
***** DUA00740
*****INPUT : NUMBER OF POINTS IN X AND Y SUB REF. GRID***** DUA00750
***** DUA00760
PARAMETER (MXSX = 61 ) DUA00770
PARAMETER (MXSY = 61 ) DUA00780
***** DUA00790
PARAMETER (TMXMX = MXMX + 1 ) DUA00800
PARAMETER (TMXMY = MXMY + 1 ) DUA00810
PARAMETER (TMXSX = MXSX + 1 ) DUA00820
PARAMETER (TMXSY = MXSY + 1 ) DUA00830
***** DUA00840
*****INPUT : NUMBER OF FAR-FIELD GRID POINTS***** DUA00850
***** DUA00860
PARAMETER (MXTHE = 50 ) DUA00870
PARAMETER (MXPHI = 360 ) DUA00880
***** DUA00890
PARAMETER (MXYZ = 4 ) DUA00900
PARAMETER (DXYZ = 3 ) DUA00910
PARAMETER (LNRY = 1 ) DUA00920
PARAMETER (VDTX = 4 ) DUA00930
PARAMETER (NDTX = 3 ) DUA00940
PARAMETER (MDTX = 10 ) DUA00950
PARAMETER (KDTX = 18 ) DUA00960
***** DUA00970
** INTRINSIC FUNCTIONS DUA00980
***** DUA00990
INTRINSIC SQRT DUA01000
INTRINSIC SIN DUA01010
INTRINSIC COS DUA01020
INTRINSIC ACOS DUA01030
INTRINSIC NINT DUA01040
***** DUA01050
** EXTERNAL FUNCTIONS DUA01060
***** DUA01070
REAL DOT DUA01080
EXTERNAL DOT DUA01090
REAL FDPTRN DUA01100
EXTERNAL FDPTRN DUA01110
***** DUA01120
** EXTERNAL SUBROUTINES DUA01130
***** DUA01140
EXTERNAL CROSS DUA01150
EXTERNAL SCALER DUA01160
EXTERNAL VECADD DUA01170
EXTERNAL VECSUB DUA01180
***** DUA01190
** RUN TIME CONSTANTS DUA01200

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*****DUA01210
      REAL      DTAARY(MDTX)      DUA01220
      REAL      DMX,DMY           DUA01230
      REAL      INCMX,INCMY       DUA01240
      REAL      DSX,DSY           DUA01250
      REAL      INCSX,INCSY       DUA01260
      INTEGER    MAXMX,MAXMY      DUA01270
      INTEGER    MAXSX,MAXSY      DUA01280
      REAL      FREQ              DUA01290
      REAL      Q                 DUA01300
*****DUA01310
** EQUIVALENCE                      DUA01320
*****DUA01330
      EQUIVALENCE (DTAARY( 1),DMX )      DUA01340
      EQUIVALENCE (DTAARY( 2),DMY )      DUA01350
      EQUIVALENCE (DTAARY( 3),INCMX)     DUA01360
      EQUIVALENCE (DTAARY( 4),INCMY)     DUA01370
      EQUIVALENCE (DTAARY( 5),DSX )      DUA01380
      EQUIVALENCE (DTAARY( 6),DSY )      DUA01390
      EQUIVALENCE (DTAARY( 7),INCSX)     DUA01400
      EQUIVALENCE (DTAARY( 8),INCSY)     DUA01410
      EQUIVALENCE (DTAARY( 9),FREQ )     DUA01420
      EQUIVALENCE (DTAARY(10),Q )        DUA01430
*****DUA01440
** RUN      TIME VARIABLES          DUA01450
*****DUA01460
      REAL      LAMBDA             DUA01470
      REAL      K                 DUA01480
*****DUA01490
** EQUIVALENCE                      DUA01500
*****DUA01510
** Input Arrays                     DUA01520
** MAIFIL ==> MAIARY()             DUA01530
** SUBFIL  ==> SUBARY()            DUA01540
** XYZFIL  ==> XYZARY() ==> MRXYZO(),SRXYZO(),FEDXYZ(),REFXYZ() DUA01550
** DTAFIL  ==> DTAARY() ==> DMX,DMY,INCMX,INCMY,DSX,DSY,INCSX,INCSY,FREQ DUA01560
*****DUA01570
*****READ IN THE XYZARY AND DTAARY FROM FILE GENERATOR*****DUA01580
*****DUA01590
      DO 10 I=1,10                 DUA01600
      READ(15,805) DTAARY(I)       DUA01610
805  FORMAT(5X,E15.8)              DUA01620
10   CONTINUE                      DUA01630
*****DUA01640
*****DUA01650
** Initial Calculations             DUA01660
*****DUA01670
      LAMBDA = C/FREQ              DUA01680
      K      = 2*PI/LAMBDA         DUA01690
      MAXMX  = (NINT(DMX/INCMX) + 1) DUA01700
      MAXMY  = (NINT(DMY/INCMY) + 1) DUA01710
      MAXSX  = (NINT(DSX/INCSX) + 1) DUA01720
      MAXSY  = (NINT(DSY/INCSY) + 1) DUA01730
      CALL SUBMAI(MAXMX,MAXMY,MAXSX,MAXSY,MDTX,DTAARY) DUA01740
      END                          DUA01750
*****DUA01760
*****MAIN PROGRAM*****DUA01770
*****DUA01780
      SUBROUTINE SUBMAI(PMXMX,PMXMY,PMXSX,PMXSY,PDTX,DTXARX) DUA01790
      INTEGER      PMXMX           DUA01800

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INTEGER	PMXMY		DUA01810
INTEGER	PMXSX		DUA01820
INTEGER	PMXSY		DUA01830
INTEGER	PDTX		DUA01840
REAL	DTXARX(PDTX)		DUA01850
*****			DUA01860
** COMPILE CONSTANTS			DUA01870
*****			DUA01880
REAL	C		DUA01890
PARAMETER	(C = 2.99792458E+08)		DUA01900
REAL	PI		DUA01910
PARAMETER	(PI = 3.141592653589793238)		DUA01920
REAL	ETA		DUA01930
PARAMETER	(ETA = 4.0*PI*C*(1.E-7))		DUA01940
REAL	R2DEG		DUA01950
PARAMETER	(R2DEG = 180./PI)		DUA01960
REAL	D2RAD		DUA01970
PARAMETER	(D2RAD = PI/180.)		DUA01980
INTEGER	IDXZ		DUA01990
INTEGER	IDXZX		DUA02000
INTEGER	IDXZY		DUA02010
INTEGER	IDXMSK		DUA02020
INTEGER	IDXVCX		DUA02030
INTEGER	IDXVCY		DUA02040
INTEGER	IDXVCZ		DUA02050
INTEGER	IDXRMJ		DUA02060
INTEGER	IDXIMJ		DUA02070
INTEGER	IDXUNM		DUA02080
INTEGER	IDXJVX		DUA02090
INTEGER	IDXNRM		DUA02100
INTEGER	IDXDTX		DUA02110
INTEGER	IDXMNM		DUA02120
INTEGER	IDXMSI		DUA02130
INTEGER	IDXAOT		DUA02140
INTEGER	IDXPWR		DUA02150
INTEGER	IDXADB		DUA02160
INTEGER	IDXRDB		DUA02170
INTEGER	MXMX, MXMY, TMXMX, TMXMY		DUA02180
INTEGER	MXSX, MXSY, TMXSX, TMXSY		DUA02190
INTEGER	MXTHE, MXPFI		DUA02200
INTEGER	MXYZ		DUA02210
INTEGER	DXYZ		DUA02220
INTEGER	LNRY		DUA02230
INTEGER	VDTX		DUA02240
INTEGER	NDTX		DUA02250
INTEGER	MDTX		DUA02260
INTEGER	KDTX		DUA02270
PARAMETER	(IDXZ = 1)		DUA02280
PARAMETER	(IDXZX = 2)		DUA02290
PARAMETER	(IDXZY = 3)		DUA02300
PARAMETER	(IDXMSK = 4)		DUA02310
PARAMETER	(IDXVCX = 1)		DUA02320
PARAMETER	(IDXVCY = 2)		DUA02330
PARAMETER	(IDXVCZ = 3)		DUA02340
PARAMETER	(IDXRMJ = 1)		DUA02350
PARAMETER	(IDXIMJ = 2)		DUA02360
PARAMETER	(IDXUNM = 3)		DUA02370
PARAMETER	(IDXJVX = 1)		DUA02380
PARAMETER	(IDXNRM = 2)		DUA02390
PARAMETER	(IDXDTX = 3)		DUA02400


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PARAMETER (IDXMMN = 1 ) DUA02410
PARAMETER (IDXMSI = 2 ) DUA02420
PARAMETER (IDXAOT = 3 ) DUA02430
PARAMETER (IDXPWR = 1 ) DUA02440
PARAMETER (IDXADB = 2 ) DUA02450
PARAMETER (IDXRDB = 3 ) DUA02460
***** DUA02470
*****INPUT : NUMBER OF POINTS IN X AND Y MAIN REF. GRID***** DUA02480
***** DUA02490
PARAMETER (MXMX = 101 ) DUA02500
PARAMETER (MXMY = 101 ) DUA02510
***** DUA02520
*****INPUT : NUMBER OF POINTS IN X AND Y SUB REF. GRID***** DUA02530
***** DUA02540
PARAMETER (MXSX = 61 ) DUA02550
PARAMETER (MXSY = 61 ) DUA02560
***** DUA02570
PARAMETER (TMXMX = MXMX + 1 ) DUA02580
PARAMETER (TMXMY = MXMY + 1 ) DUA02590
PARAMETER (TMXSX = MXSX + 1 ) DUA02600
PARAMETER (TMXSY = MXSY + 1 ) DUA02610
***** DUA02620
***** INPUT : FAR-FIELD GRID POINTS THETA AND PHI***** DUA02630
***** DUA02640
PARAMETER (MXTHE = 50 ) DUA02650
PARAMETER (MXPHI = 360 ) DUA02660
***** DUA02670
PARAMETER (MXYZ = 4 ) DUA02680
PARAMETER (DXYZ = 3 ) DUA02690
PARAMETER (LNRY = 1 ) DUA02700
PARAMETER (VDTX = 4 ) DUA02710
PARAMETER (NDTX = 3 ) DUA02720
PARAMETER (MDTX = 10 ) DUA02730
PARAMETER (KDTX = 18 ) DUA02740
***** DUA02750
** INTRINSIC FUNCTIONS DUA02760
***** DUA02770
INTRINSIC SQRT DUA02780
INTRINSIC SIN DUA02790
INTRINSIC COS DUA02800
INTRINSIC ACOS DUA02810
INTRINSIC NINT DUA02820
***** DUA02830
** EXTERNAL FUNCTIONS DUA02840
***** DUA02850
REAL DOT DUA02860
EXTERNAL DOT DUA02870
REAL FDPTRN DUA02880
EXTERNAL FDPTRN DUA02890
***** DUA02900
** EXTERNAL SUBROUTINES DUA02910
***** DUA02920
EXTERNAL CROSS DUA02930
EXTERNAL SCALER DUA02940
EXTERNAL VECADD DUA02950
EXTERNAL VECSUB DUA02960
***** DUA02970
** RUN TIME CONSTANTS DUA02980
***** DUA02990
REAL MAIARY(VDTX, TMXMY, TMXMX) DUA03000

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REAL	SUBARY(VDTX, TMXSY, TMXSX)	DUA03010
REAL	XYZARY(DXYZ, MXYZ)	DUA03020
REAL	SRXYZO(DXYZ), XS0, YS0, ZS0	DUA03030
REAL	MRXYZO(DXYZ), XM0, YM0, ZM0	DUA03040
REAL	FEDXYZ(DXYZ), XF, YF, ZF	DUA03050
REAL	REFXYZ(DXYZ), XR, YR, ZR	DUA03060
REAL	SR(DXYZ), SRX, SRY, SRZ	DUA03070
REAL	USR(DXYZ), USRX, USRY, USRZ	DUA03080
REAL	MAGSR	DUA03090
REAL	DTAARY(MDTX)	DUA03100
REAL	DMX, DMY	DUA03110
REAL	INCMX, INCMY	DUA03120
REAL	DSX, DSY	DUA03130
REAL	INCSX, INCSY	DUA03140
REAL	FREQ	DUA03150
REAL	Q	DUA03160
REAL	DTXARY(KDTX)	DUA03170
REAL	BEGPHX	DUA03180
REAL	ENDPHX	DUA03190
REAL	IDXPHX	DUA03200
REAL	STPPHX	DUA03210
REAL	INCPHX	DUA03220
REAL	BEGTHX	DUA03230
REAL	ENDTHX	DUA03240
REAL	IDXTHX	DUA03250
REAL	STPTHX	DUA03260
REAL	INCTHX	DUA03270
REAL	PTTMNX	DUA03280
REAL	PTTMXX	DUA03290
REAL	ADBMNX	DUA03300
REAL	ADBMX	DUA03310
REAL	RDBMNX	DUA03320
REAL	PRAD	DUA03330
REAL	RINTNS	DUA03340
REAL	RIFCTR	DUA03350
REAL	DIRECTV	DUA03360

** EQUIVALENCE

EQUIVALENCE	(XYZARY(1,1), MRXYZO(1))	DUA03370
EQUIVALENCE	(XYZARY(1,2), SRXYZO(1))	DUA03380
EQUIVALENCE	(XYZARY(1,3), FEDXYZ(1))	DUA03390
EQUIVALENCE	(XYZARY(1,4), REFXYZ(1))	DUA03400
EQUIVALENCE	(MRXYZO(1), XM0)	DUA03410
EQUIVALENCE	(MRXYZO(2), YM0)	DUA03420
EQUIVALENCE	(MRXYZO(3), ZM0)	DUA03430
EQUIVALENCE	(SRXYZO(1), XS0)	DUA03440
EQUIVALENCE	(SRXYZO(2), YS0)	DUA03450
EQUIVALENCE	(SRXYZO(3), ZS0)	DUA03460
EQUIVALENCE	(FEDXYZ(1), XF)	DUA03470
EQUIVALENCE	(FEDXYZ(2), YF)	DUA03480
EQUIVALENCE	(FEDXYZ(3), ZF)	DUA03490
EQUIVALENCE	(REFXYZ(1), XR)	DUA03500
EQUIVALENCE	(REFXYZ(2), YR)	DUA03510
EQUIVALENCE	(REFXYZ(3), ZR)	DUA03520
EQUIVALENCE	(SR(1), SRX)	DUA03530
EQUIVALENCE	(SR(2), SRY)	DUA03540
EQUIVALENCE	(SR(3), SRZ)	DUA03550
EQUIVALENCE	(USR(1), USRX)	DUA03560
EQUIVALENCE	(USR(2), USRY)	DUA03570
EQUIVALENCE	(USR(3), USRZ)	DUA03580
EQUIVALENCE	(USR(1), USRX)	DUA03590
EQUIVALENCE	(USR(2), USRY)	DUA03600

EQUIVALENCE (USR (3),USRZ)	DUA03610
EQUIVALENCE (DTAARY(1),DMX)	DUA03620
EQUIVALENCE (DTAARY(2),DMY)	DUA03630
EQUIVALENCE (DTAARY(3),INCMX)	DUA03640
EQUIVALENCE (DTAARY(4),INCMY)	DUA03650
EQUIVALENCE (DTAARY(5),DSX)	DUA03660
EQUIVALENCE (DTAARY(6),DSY)	DUA03670
EQUIVALENCE (DTAARY(7),INCSX)	DUA03680
EQUIVALENCE (DTAARY(8),INCSY)	DUA03690
EQUIVALENCE (DTAARY(9),FREQ)	DUA03700
EQUIVALENCE (DTAARY(10),Q)	DUA03710
EQUIVALENCE (DTXARY(1),BEGPHX)	DUA03720
EQUIVALENCE (DTXARY(2),ENDPHX)	DUA03730
EQUIVALENCE (DTXARY(3),IDXPXH)	DUA03740
EQUIVALENCE (DTXARY(4),STPPHX)	DUA03750
EQUIVALENCE (DTXARY(5),INCPHX)	DUA03760
EQUIVALENCE (DTXARY(6),BEGTHX)	DUA03770
EQUIVALENCE (DTXARY(7),ENDTHX)	DUA03780
EQUIVALENCE (DTXARY(8),IDXTHX)	DUA03790
EQUIVALENCE (DTXARY(9),STPTHX)	DUA03800
EQUIVALENCE (DTXARY(10),INCTHX)	DUA03810
EQUIVALENCE (DTXARY(11),PTTMNX)	DUA03820
EQUIVALENCE (DTXARY(12),PTTMXX)	DUA03830
EQUIVALENCE (DTXARY(13),ADBMMX)	DUA03840
EQUIVALENCE (DTXARY(14),ADBMMX)	DUA03850
EQUIVALENCE (DTXARY(15),RDBMMX)	DUA03860
EQUIVALENCE (DTXARY(16),PRAD)	DUA03870
EQUIVALENCE (DTXARY(17),RINTNS)	DUA03880
EQUIVALENCE (DTXARY(18),DIRCTV)	DUA03890
*****	DUA03900
** RUN TIME VARIABLES	DUA03910
*****	DUA03920
REAL MCDARY(DXYZ,DXYZ,TMXY,TMXX)	DUA03930
REAL SCDARY(DXYZ,DXYZ,TMSY,TMSX)	DUA03940
REAL MAIXYZ(DXYZ),XM, YM, ZM	DUA03950
REAL SUBXYZ(DXYZ),XS, YS, ZS	DUA03960
REAL GENXYZ(DXYZ),XI, YJ, ZIJ	DUA03970
REAL TMPXYZ(DXYZ,2)	DUA03980
REAL TMRXYZ(DXYZ),TMRX,TMRY,TMRZ	DUA03990
REAL TMIXYZ(DXYZ),TMIX,TMIY,TMIZ	DUA04000
REAL HFLD(DXYZ,2)	DUA04010
REAL HVR (DXYZ),HVRX,HVRY,HVRZ	DUA04020
REAL HVI (DXYZ),HVIX,HVIY,HVIZ	DUA04030
REAL JFLD(DXYZ,2)	DUA04040
REAL JVR (DXYZ),JVRX,JVRY,JVRZ	DUA04050
REAL JVI (DXYZ),JVIX,JVIY,JVIZ	DUA04060
REAL SUM (DXYZ,2)	DUA04070
REAL SUMR(DXYZ),SUMRX,SUMRY,SUMRZ	DUA04080
REAL SUMI(DXYZ),SUMIX,SUMIY,SUMIZ	DUA04090
REAL NORM(DXYZ),NX ,NY ,NZ	DUA04100
REAL MAGNRM	DUA04110
REAL SI (DXYZ),SIX ,SIY ,SIZ	DUA04120
REAL USI (DXYZ),USIX,USIY,USIZ	DUA04130
REAL MAGSI	DUA04140
REAL PV (DXYZ),PVX ,PVY ,PVZ	DUA04150
REAL UPV (DXYZ),UPVX,UPVY,UPVZ	DUA04160
REAL MAGPV	DUA04170
REAL HV (DXYZ),HVX ,HVY ,HVZ	DUA04180
REAL UHV (DXYZ),UHVX,UHVIY,UHVZ	DUA04190
REAL MAGHV	DUA04200

REAL	JV (DXYZ),JVX ,JVV ,JVZ	DUA04210
REAL	UJV(DXYZ),UJVX,UJVV,UJVZ	DUA04220
REAL	MAGJV	DUA04230
REAL	R1 (DXYZ),R1X ,R1Y ,R1Z	DUA04240
REAL	UR1(DXYZ),UR1X,UR1Y,UR1Z	DUA04250
REAL	MAGR1	DUA04260
REAL	INTG(DXYZ),INTX,INTY,INTZ	DUA04270
REAL	MAGINT	DUA04280
REAL	RFF (DXYZ),RFFX,RFFY,RFFZ	DUA04290
REAL	PTTRN(NDTX,0:MXTHE,0:MXPHI)	DUA04300
REAL	PTTMIN	DUA04310
REAL	PTTMAX	DUA04320
REAL	LAMBDA	DUA04330
REAL	K	DUA04340
REAL	KR	DUA04350
REAL	RR	DUA04360
REAL	PSI(2),COSKR,SINKR	DUA04370
REAL	MIN	DUA04380
REAL	MAX	DUA04390
REAL	R1TMP	DUA04400
REAL	R2TMP	DUA04410
REAL	CMPTMP(2),CMPTMR,CMPTMI	DUA04420
REAL	SCALE	DUA04430
REAL	ANGLE	DUA04440
INTEGER	ANGPHX	DUA04450
REAL	ANGPHI	DUA04460
REAL	BEGPHI	DUA04470
REAL	ENDPHI	DUA04480
INTEGER	IDXPHI	DUA04490
INTEGER	STPPHI	DUA04500
REAL	INCPHI	DUA04510
REAL	SINPHI	DUA04520
REAL	COSPHI	DUA04530
INTEGER	ANGTHX	DUA04540
REAL	ANGTHE	DUA04550
REAL	BEGTHE	DUA04560
REAL	ENDTHE	DUA04570
INTEGER	IDXTHE	DUA04580
INTEGER	STPTHE	DUA04590
REAL	INCTHE	DUA04600
REAL	SINTHE	DUA04610
REAL	COSTHE	DUA04620
REAL	EPHRE	DUA04630
REAL	EPHIM	DUA04640
REAL	ETHRE	DUA04650
REAL	ETHIM	DUA04660
REAL	COZ	DUA04670
REAL	MSKFAC	DUA04680
INTEGER	MAXMX,MAXMY	DUA04690
INTEGER	MAXSX,MAXSY	DUA04700
REAL	DS	DUA04710
REAL	INCMXY	DUA04720
REAL	INCSXY	DUA04730
INTEGER	I,J,IP,JP,V,W	DUA04740
INTEGER	IOS	DUA04750
INTEGER	FLG	DUA04760
INTEGER	ITMP	DUA04770
CHARACTER	TIME*8	DUA04780
REAL	AAAKR	DUA04790
INTEGER	IIIKR	DUA04800

*****	DUA04810
** EQUIVALENCE	DUA04820
*****	DUA04830
EQUIVALENCE (SUBXYZ(1),XS)	DUA04840
EQUIVALENCE (SUBXYZ(2),YS)	DUA04850
EQUIVALENCE (SUBXYZ(3),ZS)	DUA04860
EQUIVALENCE (MAIXYZ(1),XM)	DUA04870
EQUIVALENCE (MAIXYZ(2),YM)	DUA04880
EQUIVALENCE (MAIXYZ(3),ZM)	DUA04890
EQUIVALENCE (GENXYZ(1),XI)	DUA04900
EQUIVALENCE (GENXYZ(2),YJ)	DUA04910
EQUIVALENCE (GENXYZ(3),ZIJ)	DUA04920
EQUIVALENCE (TMPXYZ(1,1),TMRXYZ(1))	DUA04930
EQUIVALENCE (TMPXYZ(1,2),TMIXYZ(1))	DUA04940
EQUIVALENCE (TMRXYZ(1),TMRX)	DUA04950
EQUIVALENCE (TMRXYZ(2),TMRX)	DUA04960
EQUIVALENCE (TMRXYZ(3),TMRZ)	DUA04970
EQUIVALENCE (TMIXYZ(1),TMIX)	DUA04980
EQUIVALENCE (TMIXYZ(2),TMIY)	DUA04990
EQUIVALENCE (TMIXYZ(3),TMIZ)	DUA05000
EQUIVALENCE (SUM(1,1),SUMR(1))	DUA05010
EQUIVALENCE (SUM(1,2),SUMI(1))	DUA05020
EQUIVALENCE (SUMR (1),SUMRX)	DUA05030
EQUIVALENCE (SUMR (2),SUMRY)	DUA05040
EQUIVALENCE (SUMR (3),SUMRZ)	DUA05050
EQUIVALENCE (SUMI (1),SUMIX)	DUA05060
EQUIVALENCE (SUMI (2),SUMIY)	DUA05070
EQUIVALENCE (SUMI (3),SUMIZ)	DUA05080
EQUIVALENCE (NORM (1),NX)	DUA05090
EQUIVALENCE (NORM (2),NY)	DUA05100
EQUIVALENCE (NORM (3),NZ)	DUA05110
EQUIVALENCE (SI (1),SIX)	DUA05120
EQUIVALENCE (SI (2),SIY)	DUA05130
EQUIVALENCE (SI (3),SIZ)	DUA05140
EQUIVALENCE (USI (1),USIX)	DUA05150
EQUIVALENCE (USI (2),USIY)	DUA05160
EQUIVALENCE (USI (3),USIZ)	DUA05170
EQUIVALENCE (PV (1),PVX)	DUA05180
EQUIVALENCE (PV (2),PVY)	DUA05190
EQUIVALENCE (PV (3),PVZ)	DUA05200
EQUIVALENCE (UPV (1),UPVX)	DUA05210
EQUIVALENCE (UPV (2),UPVY)	DUA05220
EQUIVALENCE (UPV (3),UPVZ)	DUA05230
EQUIVALENCE (HFLD(1,1),HVR(1))	DUA05240
EQUIVALENCE (HFLD(1,2),HVI(1))	DUA05250
EQUIVALENCE (HVR (1),HVRX)	DUA05260
EQUIVALENCE (HVR (2),HVRX)	DUA05270
EQUIVALENCE (HVR (3),HVRZ)	DUA05280
EQUIVALENCE (HVI (1),HVIX)	DUA05290
EQUIVALENCE (HVI (2),HVIY)	DUA05300
EQUIVALENCE (HVI (3),HVIZ)	DUA05310
EQUIVALENCE (HV (1),HVX)	DUA05320
EQUIVALENCE (HV (2),HVIY)	DUA05330
EQUIVALENCE (HV (3),HVZ)	DUA05340
EQUIVALENCE (UHV (1),UHVX)	DUA05350
EQUIVALENCE (UHV (2),UHVY)	DUA05360
EQUIVALENCE (UHV (3),UHVZ)	DUA05370
EQUIVALENCE (JFLD(1,1),JVR(1))	DUA05380
EQUIVALENCE (JFLD(1,2),JVI(1))	DUA05390
EQUIVALENCE (JVR (1),JVRX)	DUA05400

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EQUIVALENCE (JVR (2),JVRZ ) DUA05410
EQUIVALENCE (JVR (3),JVRZ ) DUA05420
EQUIVALENCE (JVI (1),JVIY ) DUA05430
EQUIVALENCE (JVI (2),JVIY ) DUA05440
EQUIVALENCE (JVI (3),JVIY ) DUA05450
EQUIVALENCE (JV (1),JVX ) DUA05460
EQUIVALENCE (JV (2),JVY ) DUA05470
EQUIVALENCE (JV (3),JVZ ) DUA05480
EQUIVALENCE (UJV (1),UJVX ) DUA05490
EQUIVALENCE (UJV (2),UJVY ) DUA05500
EQUIVALENCE (UJV (3),UJVZ ) DUA05510
EQUIVALENCE (R1 (1),R1X ) DUA05520
EQUIVALENCE (R1 (2),R1Y ) DUA05530
EQUIVALENCE (R1 (3),R1Z ) DUA05540
EQUIVALENCE (UR1 (1),UR1X ) DUA05550
EQUIVALENCE (UR1 (2),UR1Y ) DUA05560
EQUIVALENCE (UR1 (3),UR1Z ) DUA05570
EQUIVALENCE (INTG (1),INTX ) DUA05580
EQUIVALENCE (INTG (2),INTY ) DUA05590
EQUIVALENCE (INTG (3),INTZ ) DUA05600
EQUIVALENCE (RFF (1),RFFX ) DUA05610
EQUIVALENCE (RFF (2),RFFY ) DUA05620
EQUIVALENCE (RFF (3),RFFZ ) DUA05630
EQUIVALENCE (PSI (1),COSKR) DUA05640
EQUIVALENCE (PSI (2),SINKR) DUA05650
EQUIVALENCE (CMPTMP(1),CMPTMR) DUA05660
EQUIVALENCE (CMPTMP(2),CMPTMI) DUA05670
*****DUA05680
** INITIALIZE INPUT ARRAYS DUA05690
** MAIFIL ==> MAIARY() DUA05700
** SUBFIL ==> SUBARY() DUA05710
** XYZFIL ==> XYZARY() ==> MRXYZO(),SRXYZO(),FEDXYZ(),REFXYZ() DUA05720
** DTAFIL ==> DTAARY() ==> DMX,DMY,INCMX,INCMY,DSX,DSY,INCSX,INCSY,FREQ,DUA05730
*****DUA05740
** GENERATE OUTPUT ARRAYS DUA05750
** MCDFIL <== MCDARY() DUA05760
** SCDFIL <== SCDARY() DUA05770
** RFXFIL <== PTTN ( ) DUA05780
** DTXFIL <== DTXARY() <== BEG,END,IDX,STP,INC * THE,PHI , PTT * ADR * DUA05790
*****DUA05800
*****READ IN THE XYZARY,SUBARY,MAIARY ARRAYS FROM FILE GEN.*****DUA05810
*****DUA05820
DO 11 II=1,4 DUA05830
DO 12 JJ=1,3 DUA05840
READ(16,806)XYZARY(JJ,II) DUA05850
806 FORMAT(5X,E15.8) DUA05860
12 CONTINUE DUA05870
11 CONTINUE DUA05880
*****DUA05890
*****DUA05900
DO 13 III=1,TMXSX,1 DUA05910
DO 14 JJJ=1,TMXSY,1 DUA05920
READ(17,807)SUBARY(IDXZ,JJJ,III), DUA05930
1 SUBARY(IDXZX,JJJ,III), DUA05940
2 SUBARY(IDXZY,JJJ,III), DUA05950
3 SUBARY(IDXMSK,JJJ,III) DUA05960
807 FORMAT(5X,4(E15.8,2X)) DUA05970
14 CONTINUE DUA05980
13 CONTINUE DUA05990
DO 15 IIII=1,TMXMX,1 DUA06000

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DO 16 JJJJ=1,TXMY,1
READ(18,807)MAIARY(IDXZ,JJJJ,IIII),
1      MAIARY(IDXZX,JJJJ,IIII),
2      MAIARY(IDXZY,JJJJ,IIII),
3      MAIARY(IDXMSK,JJJJ,IIII)
16      CONTINUE
15      CONTINUE
*****
** INITIAL CALCULATIONS
*****
DO 00100 I = 1,PDX,1
DTAARY(I) = DTXARX(I)
00100 CONTINUE
LAMBDA = C/FREQ
K = 2*PI/LAMBDA
MAXMX = PMXMX
MAXMY = PMXMY
MAXSX = PMXSX
MAXSY = PMXSY
MAGSR = 0
DO 00200 V = 1,3,1
R1TMP = REFXYZ(V) - FEDXYZ(V)
SR(V) = R1TMP
MAGSR = MAGSR + R1TMP*R1TMP
00200 CONTINUE
MAGSR=SQRT(MAGSR)
DO 00300 V = 1,3,1
USR(V) = SR(V)/MAGSR
00300 CONTINUE
*****
*****INPUT : FAR-FIELD LIMIT POINTS*****
***** E-PLANE : 90 - 270 PHI CUTS
***** H-PLANE : 0 - 180 PHI CUTS
***** 45-PLANE: 45 - 225 PHI CUTS
*****
BEGPHI = 74.99858*pi/180.
ENDPHI = 254.99858*pi/180.
IDXPFI = 1
STPPHI = 1
INCPHI = (ENDPHI-BEGPHI)/IDXPFI
* INCPHI = 0
*****
BEGTHE = 0.
ENDTHE = 5.*PI/180
IDXTHE = 50
STPTHE = 1
INCTHE = (ENDTHE-BEGTHE)/IDXTHE
*****
** Calculate Current Densities on the SubReflector Resulting from Source
*****
INCSXY = INCSX*INCSY
XS = XS0 - INCSX
DO 00700 I = 1,MAXSX,1
XS = XS + INCSX
YS = YS0 - INCSY
DO 00600 J = 1,MAXSY,1
YS = YS + INCSY
ZS = SUBARY(IDXZ,J,I)
MSKFAC = SUBARY(IDXMSK,J,I)
IF (MSKFAC .EQ. 1.) THEN

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	MAGSI = 0.	DUA06610
	DO 00500 V = 1,3,1	DUA06620
	R1TMP = SUBXYZ(V) - FEDXYZ(V)	DUA06630
	SI(V) = R1TMP	DUA06640
	MAGSI = MAGSI + R1TMP*R1TMP	DUA06650
00500	CONTINUE	DUA06660
	MAGSI=SQRT(MAGSI)	DUA06670
	IF (MAGSI .EQ. 0.) THEN	DUA06680
	STOP	DUA06690
	ENDIF	DUA06700
	DO 00510 V = 1,3,1	DUA06710
	USI(V) = SI(V)/MAGSI	DUA06720
00510	CONTINUE	DUA06730
	PVX = (-USIX*USIY)	DUA06740
	PVY = (USIX*USIX + USIZ*USIZ)	DUA06750
	PVZ = (-USIY*USIZ)	DUA06760
	MAGPV = SQRT(PVX*PVX + PVY*PVY + PVZ*PVZ)	DUA06770
	DO 00520 V = 1,3,1	DUA06780
	UPV(V) = PV(V)/MAGPV	DUA06790
00520	CONTINUE	DUA06800
*	COSTHE = DOT(USR,UPV,3)	DUA06810
	SCALE = FDPTRN(USR,USI,Q,COZ,FLG)/ETA	DUA06820
	IF ((FLG .EQ. 1)	DUA06830
1	.OR.(SCALE .EQ. 0.)) THEN	DUA06840
STOP		DUA06850
	ENDIF	DUA06860
	CALL CROSS(HV,USI,UPV)	DUA06870
	MAGHV = SQRT(HVX*HVX + HVY*HVY + HVZ*HVZ)	DUA06880
	DO 00530 V = 1,3,1	DUA06890
	UHV(V) = HV(V)/MAGHV	DUA06900
00530	CONTINUE	DUA06910
	NX = SUBARY(IDXZX,J,I)	DUA06920
	NY = SUBARY(IDXZY,J,I)	DUA06930
	NZ = -1	DUA06940
	MAGNRM = SQRT(NX*NX + NY*NY +1)	DUA06950
	DO 00540 V = 1,3,1	DUA06960
	R1TMP = NORM(V)/MAGNRM	DUA06970
	NORM(V) = R1TMP	DUA06980
	SCDARY(V,IDXNRM,J,I) = R1TMP	DUA06990
00540	CONTINUE	DUA07000
	CALL CROSS(JV,NORM,UHV)	DUA07010
*	MAGJV = SQRT(JVX*JVX + JVV*JVV + JVZ*JVZ)	DUA07020
	MAGJV = 1.	DUA07030
	DO 00550 V = 1,3,1	DUA07040
	R1TMP = JV(V)/MAGJV	DUA07050
	UJV(V) = R1TMP	DUA07060
	SCDARY(V,IDXJVX,J,I) = R1TMP	DUA07070
00550	CONTINUE	DUA07080
	IF (MAGSI .EQ. 0.) THEN	DUA07090
	STOP	DUA07100
	ENDIF	DUA07110
	SCDARY(IDXMNM,IDXDTX,J,I)= MAGNRM	DUA07120
	SCDARY(IDXMSI,IDXDTX,J,I)= MAGSI	DUA07130
	SCDARY(IDXAOT,IDXDTX,J,I)=(2.*SCALE)	DUA07140
	SCALE = 2.*SCALE/MAGSI	DUA07150
	COSKR = COS(K*MAGSI)	DUA07160
	SINKR = SIN(K*MAGSI)	DUA07170
	JFLD(IDXVCX,IDXRMJ) = (SCALE*UJV(IDXVCX)*COSKR)	DUA07180
	JFLD(IDXVCY,IDXRMJ) = (SCALE*UJV(IDXVCY)*COSKR)	DUA07190
	JFLD(IDXVCZ,IDXRMJ) = (SCALE*UJV(IDXVCZ)*COSKR)	DUA07200

	JFLD(IDXVCX,IDXIMJ) = -(SCALE*UJV(IDXVCX)*SINKR)	DUA07210
	JFLD(IDXVCY,IDXIMJ) = -(SCALE*UJV(IDXVCY)*SINKR)	DUA07220
	JFLD(IDXVCZ,IDXIMJ) = -(SCALE*UJV(IDXVCZ)*SINKR)	DUA07230
	ELSE	DUA07240
	ENDIF	DUA07250
00599	CONTINUE	DUA07260
00600	CONTINUE	DUA07270
00700	CONTINUE	DUA07280
*****		DUA07290
** Calculate Induced Magnetic Field on Main Reflector by Sub Reflector.		DUA07300
*****		DUA07310
	INCMXY = INCMX*INCMY	DUA07320
	XM = XMO - INCMX	DUA07330
	DO 01900 IP = 1,MAXMX,1	DUA07340
	XM = XM + INCMX	DUA07350
	YM = YMO - INCMY	DUA07360
	DO 01800 JP = 1,MAXMY,1	DUA07370
	YM = YM + INCMY	DUA07380
	ZM = MAIARY(IDXZ,JP,IP)	DUA07390
	MSKFAC = MAIARY(IDXMSK,JP,IP)	DUA07400
	IF (MSKFAC .EQ. 1.) THEN	DUA07410
	NX = -(MAIARY(IDXZX,JP,IP))	DUA07420
	NY = -(MAIARY(IDXZY,JP,IP))	DUA07430
	NZ = +1.	DUA07440
	MAGNRM = SQRT(NX*NX + NY*NY +1.)	DUA07450
	DO 01100 V = 1,3,1	DUA07460
	NORM(V) = NORM(V)/MAGNRM	DUA07470
	DO 01000 W = 1,2,1	DUA07480
	HFLD(V,W) = 0.	DUA07490
01000	CONTINUE	DUA07500
01100	CONTINUE	DUA07510
	XS = XS0 - INCSX	DUA07520
	DO 01700 I = 1,MAXSX,1	DUA07530
	XS = XS + INCSX	DUA07540
	YS = YS0 - INCSY	DUA07550
	DO 01600 J = 1,MAXSY,1	DUA07560
	YS = YS + INCSY	DUA07570
	ZS = SUBARY(IDXZ,J,I)	DUA07580
	MSKFAC = SUBARY(IDXMSK,J,I)	DUA07590
	IF (MSKFAC .EQ. 1.) THEN	DUA07600
	DS = SCDARY(IDXMNM,IDXDTX,J,I)*INCSXY	DUA07610
	MAGSI = SCDARY(IDXMSI,IDXDTX,J,I)	DUA07620
	SCALE = SCDARY(IDXAOT,IDXDTX,J,I)	DUA07630
	MAGR1 = 0.	DUA07640
	DO 01200 V = 1,3,1	DUA07650
	R1TMP = (MAIXYZ(V) - SUBXYZ(V))	DUA07660
	R1(V) = R1TMP	DUA07670
	MAGR1 = MAGR1 + R1TMP*R1TMP	DUA07680
01200	CONTINUE	DUA07690
	MAGR1 = SQRT(MAGR1)	DUA07700
	DO 01300 V = 1,3,1	DUA07710
	UR1(V) = R1(V)/MAGR1	DUA07720
	UHV(V) = SCDARY(V,IDXJVX,J,I)	DUA07730
01300	CONTINUE	DUA07740
	KR = (K*(MAGR1 + MAGSI))	DUA07750
	RR = MAGR1*MAGSI	DUA07760
	COSKR = +COS(KR)/RR	DUA07770
	SINKR = -SIN(KR)/RR	DUA07780
*	CALL CROSS(INTG,SCDARY(IDXVCX,IDXJVX,J,I),UR1)	DUA07790
	CALL CROSS(INTG,UHV,UR1)	DUA07800

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*      0      MAGINT = 1.      DUA07810
*      1      MAGINT = SQRT(( (INTX*INTX)      DUA07820
*      2      + (INTY*INTY)      DUA07830
*      + (INTZ*INTZ)))      DUA07840
      INTX = INTX/MAGINT      DUA07850
      INTY = INTY/MAGINT      DUA07860
      INTZ = INTZ/MAGINT      DUA07870
DO 01500      V = 1,3,1      DUA07880
      DO 01400      W = 1,2,1      DUA07890
          HFLD(V,W) = HFLD(V,W)      DUA07900
          +SCALE*PSI(W)*INTG(V)*DS      DUA07910
      CONTINUE      DUA07920
01400      CONTINUE      DUA07930
01500      CONTINUE      DUA07940
      ENDIF      DUA07950
01599      CONTINUE      DUA07960
01600      CONTINUE      DUA07970
01700      CONTINUE      DUA07980
      MCDARY(IDXVCX,IDXUNM,JP,IP) = NX      DUA07990
      MCDARY(IDXVCY,IDXUNM,JP,IP) = NY      DUA08000
      MCDARY(IDXVCZ,IDXUNM,JP,IP) = NZ      DUA08010
      CALL SCALER(NORM,NORM,2.)      DUA08020
      CALL CROSS (JFLD(IDXVCX,IDXRMJ),NORM,HFLD(IDXVCX,IDXRMJ))      DUA08030
      CALL CROSS (JFLD(IDXVCX,IDXIMJ),NORM,HFLD(IDXVCX,IDXIMJ))      DUA08040
DO 01720      V = 1,3,1      DUA08050
      DO 01710      W = 1,2,1      DUA08060
          MCDARY(V,W,JP,IP) = JFLD(V,W)      DUA08070
01710      CONTINUE      DUA08080
01720      CONTINUE      DUA08090
*****      DUA08100
      ELSE      DUA08110
          JFLD(IDXVCX,IDXRMJ) = 0.      DUA08120
          JFLD(IDXVCY,IDXRMJ) = 0.      DUA08130
          JFLD(IDXVCZ,IDXRMJ) = 0.      DUA08140
          JFLD(IDXVCX,IDXIMJ) = 0.      DUA08150
          JFLD(IDXVCY,IDXIMJ) = 0.      DUA08160
          JFLD(IDXVCZ,IDXIMJ) = 0.      DUA08170
          MAGJV = 0.      DUA08180
      ENDIF      DUA08190
*****      DUA08200
01799      CONTINUE      DUA08210
01800      CONTINUE      DUA08220
01900      CONTINUE      DUA08230
*****      DUA08240
*** FAR FIELD ANTENNA PATTERN COMPUTATION      DUA08250
*****      DUA08260
      PTTMIN = +1.E+38      DUA08270
      PTTMAX = -1.E+38      DUA08280
      ANGPHI = BEGPHI - INCPHI      DUA08290
DO 02600      ANGPHX = 0,IDXPHI,STPPHI      DUA08300
      ANGPHI = ANGPHI + INCPHI      DUA08310
      SINPHI = SIN(ANGPHI)      DUA08320
      COSPHI = COS(ANGPHI)      DUA08330
      ANGTHE = BEGTHE - INC THE      DUA08340
DO 02500      ANGTHX = 0,IDXTHE,STPTHE      DUA08350
      ANGTHE = ANGTHE + INC THE      DUA08360
      SINTHE = SIN(ANGTHE)      DUA08370
      COSTHE = COS(ANGTHE)      DUA08380
      RFFX = SINTHE*COSPHI      DUA08390
      RFFY = SINTHE*SINPHI      DUA08400
      RFFZ = COSTHE

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	SUM(1,1) = 0.	DUA08410
	SUM(1,2) = 0.	DUA08420
	SUM(2,1) = 0.	DUA08430
	SUM(2,2) = 0.	DUA08440
	SUM(3,1) = 0.	DUA08450
	SUM(3,2) = 0.	DUA08460
	XM = XM0 - INCMX	DUA08470
	DO 02400 IP = 1,MAXMX,1	DUA08480
	XM = XM + INCMX	DUA08490
	YM = YM0 - INCMY	DUA08500
	DO 02300 JP = 1,MAXMY,1	DUA08510
	YM = YM + INCMY	DUA08520
	ZM = MAIARY(IDXZ,JP,IP)	DUA08530
	KR = (K*((RFFX*XM)+(RFFY*YM)+(RFFZ*ZM)))	DUA08540
	COSKR = COS(KR)	DUA08550
	SINKR = SIN(KR)	DUA08560
	MSKFAC = MAIARY(IDXMSK,JP,IP)	DUA08570
	IF(MSKFAC.EQ.0)GO TO 2300	DUA08580
	NORM(IDXVCX) = -MAIARY(IDXZX,JP,IP)	DUA08590
	NORM(IDXVCY) = -MAIARY(IDXZY,JP,IP)	DUA08600
	NORM(IDXVCZ) = +1.	DUA08610
0	DS = INCMXY*SQRT(NORM(IDXVCX)*NORM(IDXVCX)	DUA08620
2	+NORM(IDXVCY)*NORM(IDXVCY)	DUA08630
3	+NORM(IDXVCZ)*NORM(IDXVCZ))	DUA08640
	CMPTMP (IDXRMJ) =	DUA08650
1	RFFX*MCDARY (IDXVCX,IDXRMJ,JP,IP)	DUA08660
2	+ RFFY*MCDARY (IDXVCY,IDXRMJ,JP,IP)	DUA08670
3	+ RFFZ*MCDARY (IDXVCZ,IDXRMJ,JP,IP)	DUA08680
	CMPTMP (IDXIMJ) =	DUA08690
1	RFFX*MCDARY (IDXVCX,IDXIMJ,JP,IP)	DUA08700
2	+ RFFY*MCDARY (IDXVCY,IDXIMJ,JP,IP)	DUA08710
3	+ RFFZ*MCDARY (IDXVCZ,IDXIMJ,JP,IP)	DUA08720
	TMRX = CMPTMP (IDXRMJ)*RFFX	DUA08730
	TMRY = CMPTMP (IDXRMJ)*RFFY	DUA08740
	TMRZ = CMPTMP (IDXRMJ)*RFFZ	DUA08750
	TMIX = CMPTMP (IDXIMJ)*RFFX	DUA08760
	TMIY = CMPTMP (IDXIMJ)*RFFY	DUA08770
	TMIZ = CMPTMP (IDXIMJ)*RFFZ	DUA08780
	TMRX = MCDARY (IDXVCX,IDXRMJ,JP,IP) - TMRX	DUA08790
	TMRY = MCDARY (IDXVCY,IDXRMJ,JP,IP) - TMRY	DUA08800
	TMRZ = MCDARY (IDXVCZ,IDXRMJ,JP,IP) - TMRZ	DUA08810
	TMIX = MCDARY (IDXVCX,IDXIMJ,JP,IP) - TMIX	DUA08820
	TMIY = MCDARY (IDXVCY,IDXIMJ,JP,IP) - TMIY	DUA08830
	TMIZ = MCDARY (IDXVCZ,IDXIMJ,JP,IP) - TMIZ	DUA08840
	TTMRX = ((TMRX*COSKR)-(TMIX*SINKR))	DUA08850
	TTMRY = ((TMRY*COSKR)-(TMIY*SINKR))	DUA08860
	TTMRZ = ((TMRZ*COSKR)-(TMIZ*SINKR))	DUA08870
	TTMIX = ((TMRX*SINKR)+(TMIX*COSKR))	DUA08880
	TTMIY = ((TMRY*SINKR)+(TMIY*COSKR))	DUA08890
	TTMIZ = ((TMRZ*SINKR)+(TMIZ*COSKR))	DUA08900
	JVRX = TTMRX*DS	DUA08910
	JVRY = TTMRY*DS	DUA08920
	JVRZ = TTMRZ*DS	DUA08930
	JVIX = TTMIX*DS	DUA08940
	JVIY = TTMIY*DS	DUA08950
	JVIZ = TTMIZ*DS	DUA08960
	SUMRX = SUMRX + JVRX	DUA08970
	SUMRY = SUMRY + JVRY	DUA08980
	SUMRZ = SUMRZ + JVRZ	DUA08990
	SUMIX = SUMIX + JVIX	DUA09000

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SUMIY = SUMIY + JVIY
SUMIZ = SUMIZ + JVIZ
DUA09010
02299 CONTINUE DUA09020
02300 CONTINUE DUA09030
02400 CONTINUE DUA09040
0 ETHRE = SUMRX*COSTHE*COSPHI DUA09050
1 + SUMRY*COSTHE*SINPHI DUA09060
2 - SUMRZ*SINTHE DUA09070
0 ETHIM = SUMIX*COSTHE*COSPHI DUA09080
1 + SUMIY*COSTHE*SINPHI DUA09090
2 - SUMIZ*SINTHE DUA09100
0 EPHRE = - SUMRX*SINPHI DUA09110
1 + SUMRY*COSPHI DUA09120
0 EPHIM = - SUMIX*SINPHI DUA09130
1 + SUMIY*COSPHI DUA09140
***** DUA09150
*****ETHETA AND EPHI COMPUTED ***** DUA09160
*****TRANSFORM TO CO AND CO-POL LUDWIG'S DEFINITION***** DUA09170
***** DUA09180
AREFR=SINPHI*ETHRE+COSPHI*EPHRE DUA09190
AREFI=SINPHI*ETHIM+COSPHI*EPHIM DUA09200
ACRPR=-COSPHI*ETHRE+SINPHI*EPHRE DUA09210
ACRPI=-COSPHI*ETHIM+SINPHI*EPHIM DUA09220
***** DUA09230
AMGREF=AREFR**2+AREFI**2 DUA09240
AMGCRP=ACRPR**2+ACRPI**2 DUA09250
*****CO AND CROSS POL FIELDS ARE COMPLETED***** DUA09260
***** DUA09270
*****TOTAL FIELD***** DUA09280
* 0 R1TMP = ETHRE*ETHRE + ETHIM*ETHIM DUA09290
* 1 + EPHRE*EPHRE + EPHIM*EPHIM DUA09300
*****PLOT THE CO POL FIELDS***** DUA09310
R1TMP = AMGREF DUA09320
*****PLOT THE CROSS POL FIELDS***** DUA09330
* R1TMP = AMGCRP DUA09340
***** DUA09350
PTTRN(IDXPWR,ANGTHX,ANGPHX) = R1TMP DUA09360
IF (R1TMP.LT.PTTMIN) THEN DUA09370
PTTMIN = R1TMP DUA09380
ENDIF DUA09390
IF (R1TMP.GT.PTTMAX) THEN DUA09400
PTTMAX = R1TMP DUA09410
ENDIF DUA09420
02500 CONTINUE DUA09430
02600 CONTINUE DUA09440
PRAD = ((2.*PI)/(ETA*((2.*Q)+1))) DUA09450
RIFCTR = (((K*K*K*K)*ETA)/(256.*(PI*PI*PI*PI))) DUA09460
RINTNS = (RIFCTR*PTTMAX) DUA09470
DIRCTV = ((4.*PI*RINTNS)/(PRAD)) DUA09480
DIRCTV = (10*ALOG10(DIRCTV)) DUA09490
***** DUA09500
WRITE(19,897)DIRCTV DUA09510
897 FORMAT(5X,F15.5) DUA09520
***** DUA09530
ADBMNX = 10.*ALOG10(PTTMIN) DUA09540
ADBMXX = 10.*ALOG10(PTTMAX) DUA09550
RDBMNX = (ADBMNX - ADBMXX) DUA09560
ANGPHI = BEGPHI - INCPHI DUA09570
DO 02800 ANGPHX = 0,IDXPHI,STPPHI DUA09580
ANGPHI = ANGPHI + INCPHI DUA09590
DUA09600

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      ANGTHE = BEGTHE - INCTHE
      DO 02700  ANGTHX = 0,IDXTHE,STPTHE
      ANGTHE = ANGTHE + INCTHE
      R1TMP = 10.*ALOG10((PTTRN(IDXPWR,ANGTHX,ANGPHX)))
      PTTRN(IDXADB,ANGTHX,ANGPHX) = (R1TMP
      PTTRN(IDXRDB,ANGTHX,ANGPHX) = (R1TMP - ADBMXX)
*=====
*****GENERATE THE OUTPUT ARRAYS*****
*****
      ZETA=ANGTHE*180/PI
      APhi=ANGPHI*180/PI
      WRITE(19,895)PTTRN(IDXRDB,ANGTHX,ANGPHX),ZETA,APHI
895      FORMAT(5X,F15.8,3X,2(F15.8,3X))
02700      CONTINUE
02800 CONTINUE
      DTXARY( 2) = ENDPHI
      DTXARY( 3) = REAL(IDXPHI)
      DTXARY( 4) = REAL(STPPHI)
      DTXARY( 5) = INCPHI
      DTXARY( 6) = BEGTHE
      DTXARY( 7) = ENDTHE
      DTXARY( 8) = REAL(IDXTHE)
      DTXARY( 9) = REAL(STPTHE)
      DTXARY(10) = INCTHE
      DTXARY(11) = PTTMIN
      DTXARY(12) = PTTMAX
      END
*****
*****REAL FUNCTION FDPTRN RETURN FEED PATTERN*****
*****
      REAL FUNCTION FDPTRN(THETA,PHI,RHO,COZ,ERR)
      REAL THETA(3)
      REAL PHI(3)
      REAL RHO
      REAL COZ
      INTEGER ERR
      REAL DOT
      EXTERNAL DOT
      REAL DOTVAL
      DOTVAL = DOT(THETA,PHI,3)
      IF (DOTVAL .LT. 0.) THEN
          ERR = 1
          ERR = 1
          COZ = 0.
          FDPTRN = 0.
      ELSE
          ERR = 0
          COZ = DOTVAL
          FDPTRN = (DOTVAL)**RHO
      ENDIF
      RETURN
      END
*****
** REAL FUNCTION DOT() ! Returns Real Value of DOT PRODUCT A and B
*****
      REAL FUNCTION DOT(A,B,N)
      INTEGER N
      REAL A(N)
      REAL B(N)
      INTEGER I

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REAL	SUM	DUA10210
SUM = 0.		DUA10220
DO 00100 I = 1,N,1		DUA10230
SUM = SUM + A(I)*B(I)		DUA10240
00100 CONTINUE		DUA10250
DOT = SUM		DUA10260
RETURN		DUA10270
END		DUA10280
*****		DUA10290
** SUBROUTINE CROSS	! Performs C = AxB	DUA10300
*****		DUA10310
SUBROUTINE CROSS(C,A,B)		DUA10320
REAL C(3)		DUA10330
REAL A(3)		DUA10340
REAL B(3)		DUA10350
C(1) = +((A(2)*B(3))-(A(3)*B(2)))		DUA10360
C(2) = -((A(1)*B(3))-(A(3)*B(1)))		DUA10370
C(3) = +((A(1)*B(2))-(A(2)*B(1)))		DUA10380
END		DUA10390
*****		DUA10400
** SUBROUTINE SCALER	! Performs C = A*<SCALER>	DUA10410
*****		DUA10420
SUBROUTINE SCALER(C,A,SCALEX)		DUA10430
REAL C(3)		DUA10440
REAL A(3)		DUA10450
REAL SCALEX		DUA10460
C(1) = SCALEX*(A(1))		DUA10470
C(2) = SCALEX*(A(2))		DUA10480
C(3) = SCALEX*(A(3))		DUA10490
RETURN		DUA10500
END		DUA10510
*****		DUA10520
** SUBROUTINE VECADD	! Performs C = A+B	DUA10530
*****		DUA10540
SUBROUTINE VECADD(C,A,B)		DUA10550
REAL C(3)		DUA10560
REAL A(3)		DUA10570
REAL B(3)		DUA10580
C(1) = (A(1)+B(1))		DUA10590
C(2) = (A(2)+B(2))		DUA10600
C(3) = (A(3)+B(3))		DUA10610
RETURN		DUA10620
END		DUA10630
*****		DUA10640
** SUBROUTINE VECSUB	! Performs C = A-B	DUA10650
*****		DUA10660
SUBROUTINE VECSUB(C,A,B)		DUA10670
REAL C(3)		DUA10680
REAL A(3)		DUA10690
REAL B(3)		DUA10700
C(1) = (A(1)-B(1))		DUA10710
C(2) = (A(2)-B(2))		DUA10720
C(3) = (A(3)-B(3))		DUA10730
RETURN		DUA10740
END		DUA10750

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PROGRAM FFPL0T
DIMENSION X(10000),Y(10000),VARS(20)
DIMENSION XPL(1000),YPL(1000)
CHARACTER*13 CH/'DIRECTIVITY ='/
CHARACTER*2 ADB/'DB'/
CHARACTER*5 DIR(1)
C*****THIS PROGRAM CAN BE USED TO PLOT THE ANTENNA FAR-FIELD PATTERN
C***** (E-PLANE OR H-PLANE CUTS)
C***** IAXIS,NUM,Y,RTNARR:PARAMETERS IN SCLBK2
C***** IVAR:PARAMETERS IN GLOT3
      INTEGER * 4 IAXIS /0/
      INTEGER * 4 IVARS(20)
      INTEGER * 4 NUM/10000/
      CHARACTER*4 XTITLE(5)/'ELEV','ATIO','N AN','GLE ','DEG.'/
      CHARACTER*4 YTITLE(6)/'RELA','TIVE','AMP','LITU','DE ','(DB)'/
C*****NP : TOTAL NO. OF POINTS ; ZM: MAXM. VIEWING ANGLE(DEG.)

      READ(19,756)DDIR
756      FORMAT(5X,F15.5)
*****2(NFF+1)
      NP=102
      ZM=2.

      DO 15 J=1,NP
C*****X : ANGLE POSITIONS(DEG.) ; Y: RELATIVE FAR FLD. AMPLITUDES(DB)
      READ(19,300)YPL(J),XPL(J),DUM1
300      FORMAT(5X,F15.8,3X,2(F15.8,3X))
15      CONTINUE
      DO 98 J=1,51
      Y(J)=(YPL(103-J))
      X(J)=-XPL(103-J)
      Y(J+51)=(YPL(J))
      X(J+51)=XPL(J)
98      CONTINUE

C*****SCLKK2:GRAPH3D ROUTINE TO FIND MIN,MAX IN DATA
C***** 0 : Y-COORDINATE ; NUM : DIMENSION OF Y-ARRAY ; Y : Y-ARRAY
C*****RTNARR(2) : DIMENSION TO STORE Y(MIN),Y(MAX) VALUES
C*****REARRANGE THE FAR FIELD VALUES*****
C*****UXTRM :GRAPH3D ROUTINE; DEFINES EXTREME POSITIONS OF A 3D PLOT
C*****8 :TOTAL NO. OF VARIABLES ; 0 :CARTESIAN ; (-ZM,ZM) :(XMIN,XMAX)
C*****(-80.,0) :(YMIN,YMAX) ; (0.,0.) :(ZMIN,ZMAX)
      CALL UXTRM(8,0,-ZM,ZM,-54.,0.,0.0,0.)
C*****UMAPF :GRAPH3D ROUTINE , DEFINE MAPPING TO TRANSFORM FROM USER
C*****TO RELATIVE UNITS.
C***** 0 :CARTESIAN ; 1. :ONE VARS,DEFAULT ; 0 :NO LOG SCALE
      CALL UMAPF(0,1.,0)
C*****XAXIS3 : GRAPH3D ROUTINE , DEFINES X-AXIX COORDINATE
C***** VARS: 1=TOTAL NO OF VARS ; 2 3 4=X1 Y1 Z1 ; 5 6 7=X2 Y2 Z2
C***** 8=USER UNIT(1.) ; 9=NO. OF INTERVALS ; 10=GRID OPTION(1.)
C***** 11=DRAW PARALLEL TO Y-AXIS ; 12=VARS(9)+1 ; 13=SIZE OF LABEL
C***** 14=(DIR.OF X AXIS)(CENTERED AT GRID)(CLOCKWISE TO AXIS)
C***** 15=AXIS SETTING IS NOT COMPLETE
      VARS(1)=15
      VARS(2)=-ZM
      VARS(3)=-54.
      VARS(4)=0.0
      VARS(5)=ZM
      VARS(6)=-54.
      VARS(7)=0.

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VAR(8)=1.	FFP00600
VAR(9)=10.	FFP00610
VAR(10)=1.	FFP00620
VAR(11)=4.	FFP00630
VAR(12)=11.	FFP00640
VAR(13)=20.	FFP00650
VAR(14)=211.	FFP00660
VAR(15)=0.	FFP00670
CALL XAXIS3(VARS)	FFP00680
C*****VARS : 2 3 4 =X1 Y1 Z1 ; 5 6 7=X2 Y2 Z2 ; 8=USER UNIT ; 9=NO. OF	FFP00690
C*****INTERVALS ; 10=GRID OPTION ; 11=DRAW PARALLEL TO X-AXIS ; 12=	FFP00700
C*****VARS(9)+1 ; 13=SIZE OF LABEL ; 14=DIR. OF X-AXIS ; 15=AXIS SETTING	FFP00710
C*****COMPLETE.	FFP00720
VAR(2)=-ZM	FFP00730
VAR(3)=-54.	FFP00740
VAR(4)=0.	FFP00750
VAR(5)=-ZM	FFP00760
VAR(6)=0.	FFP00770
VAR(7)=0.	FFP00780
VAR(8)=1.	FFP00790
VAR(9)=9.	FFP00800
VAR(10)=1.	FFP00810
VAR(11)=3.	FFP00820
VAR(12)=10.	FFP00830
VAR(13)=20.	FFP00840
VAR(14)=212.	FFP00850
VAR(15)=1.	FFP00860
CALL YAXIS3(VARS)	FFP00870
C*****TITLE3 : GRAPH3D ROUTINE ; PRINTS TITLE OF X-AXIS	FFP00880
C***** 4=X-AXIS ; 20=X-ALPHANUMERIC DIMENSION ; 15=CHARACTER SIZE	FFP00890
CALL TITLE3(4,20,15,XTITLE,0.,1.,0.)	FFP00900
C*****TITLE3 : GRAPH3D ROUTINE ; PRINTS Y-AXIS TITLE	FFP00910
C***** 3=Y-AXIS ; 18=Y-ALPHANUMERIC DIMENSION ; 15=CHARACTER SIZE	FFP00920
CALL TITLE3(3,24,15,YTITLE,-1.,0.,0.)	FFP00930
C*****GLOT3 : GRAPH3D ROUTINE ; TO PLOT A CURVE WITH POINT OR VECTOR	FFP00940
C*****IVARS : 1=DIMENSION OF IVARS ; 2=NO. OF POINTS,EXACT ; 3=NO Z-AXIS	FFP00950
C***** 4=DO NOT CALL AXIS ROUTINES ; 5=POINT PLOT ; 6=SYMBOL FREQUENCY	FFP00960
C***** 7=SIZE OF SYMBOL ; 8=EXACT MIN-MAX INTERVAL	FFP00970
IVARS(1)=8	FFP00980
IVARS(2)=NP	FFP00990
IVARS(3)=0	FFP01000
IVARS(4)=0	FFP01010
IVARS(5)=0	FFP01020
IVARS(6)=1	FFP01030
IVARS(7)=15	FFP01040
IVARS(8)=1	FFP01050
CALL GLOT3(IVARS,X,Y)	FFP01060
CALL CHARS3(13,CH,3.,10.5,0.,25,1.)	FFP01070
CALL NUMBER(4,DDIR,5,2,DIR)	FFP01080
CALL CHARS3(5,DIR,7.,10.5,0.,25,1.)	FFP01090
CALL CHARS3(2,ADB,9.,10.5,0.,25,1.)	FFP01100
C*****GVIEW : GRAPH3D ROUTINE ; IDENTIFIES VIEWING ENVIRONMENT	FFP01110
C***** 1=DEFAULT VALUES FOR THREE REMAINING VARIABLES	FFP01120
CALL GVIEW(1)	FFP01130
C*****WINDW : GRAPH3D ROUTINE ; SPECIFY DIMENSION OF VIEW WINDOW	FFP01140
C***** 6=TOTAL NO OF VARIABLES ; 0=LOWEST OF THE PARAMETER RANGE	FFP01150
C*****UMIN=MIN. VALUE OF NO. OF RELATIVE UNITS FROM VIEW REFERENCE	FFP01160
C*****UMAX=MAX. VALUE OF NO.OF RELATIVE UNITS FROM VIEW REFERENCE	FFP01170
C*****VMIN= " " " " " " " " " " " "	FFP01180
C*****VMAX= " " " " " " " " " " " "	FFP01190


```
      CALL WINDW(6,0,-6.5,6.5,-6.5,6.5)
C*****DISPLA : GRAPH3D ROUTINE ; DISPLAYS INTERNAL BUFFER
C***** 1=OPTION TO CLEAR BUFFER
      CALL DISPLA(1)
C*****TERM : GRAPH3D ROUTINE ; REQUIRED TO CLOSE THE GRAPHICS
      CALL TERM
      STOP
      END
```

```
FFP01200
FFP01210
FFP01220
FFP01230
FFP01240
FFP01250
FFP01260
FFP01270
```

```
/* EXEC DUAL REFLECTOR */  
"GRAPH3D"  
SETUP FTN  
"FI 19 DISK DUALREF OUT19 A1"  
"FI 15 DISK DUALREF OUT15 A1"  
"FI 16 DISK DUALREF OUT16 A1"  
"FI 17 DISK DUALREF OUT17 A1"  
"FI 18 DISK DUALREF OUT18 A1"  
"LOAD DRSG(CLEAR START"  
"LOAD DUALREF(CLEAR START"  
"LOAD FFLOT(CLEAR START"
```

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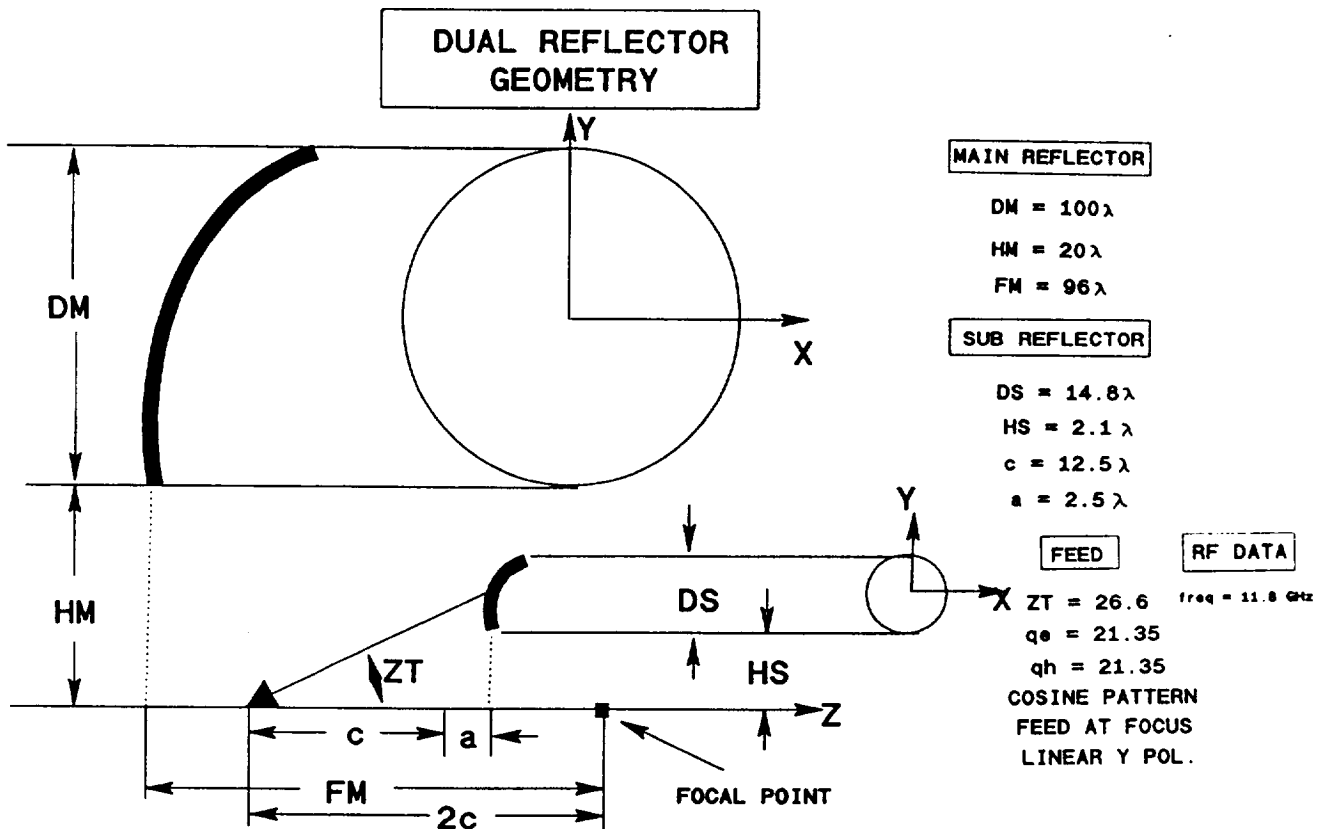


Figure 1, Dual reflector configuration

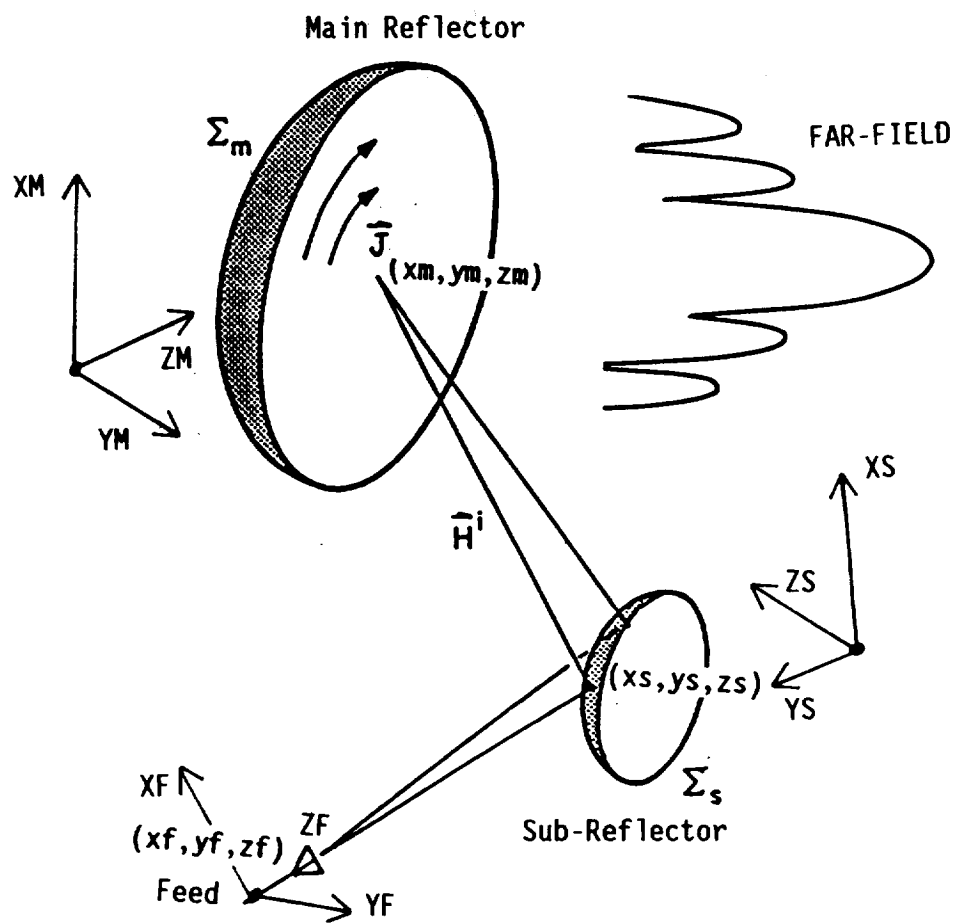


Figure 2, Generalized dual reflector geometry

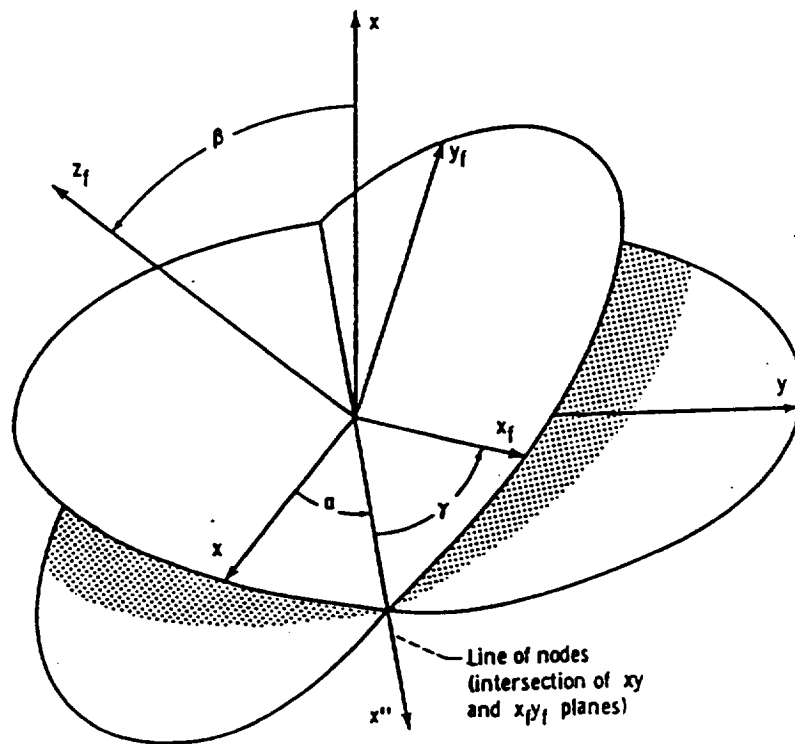


Figure 3, Eulerian angles

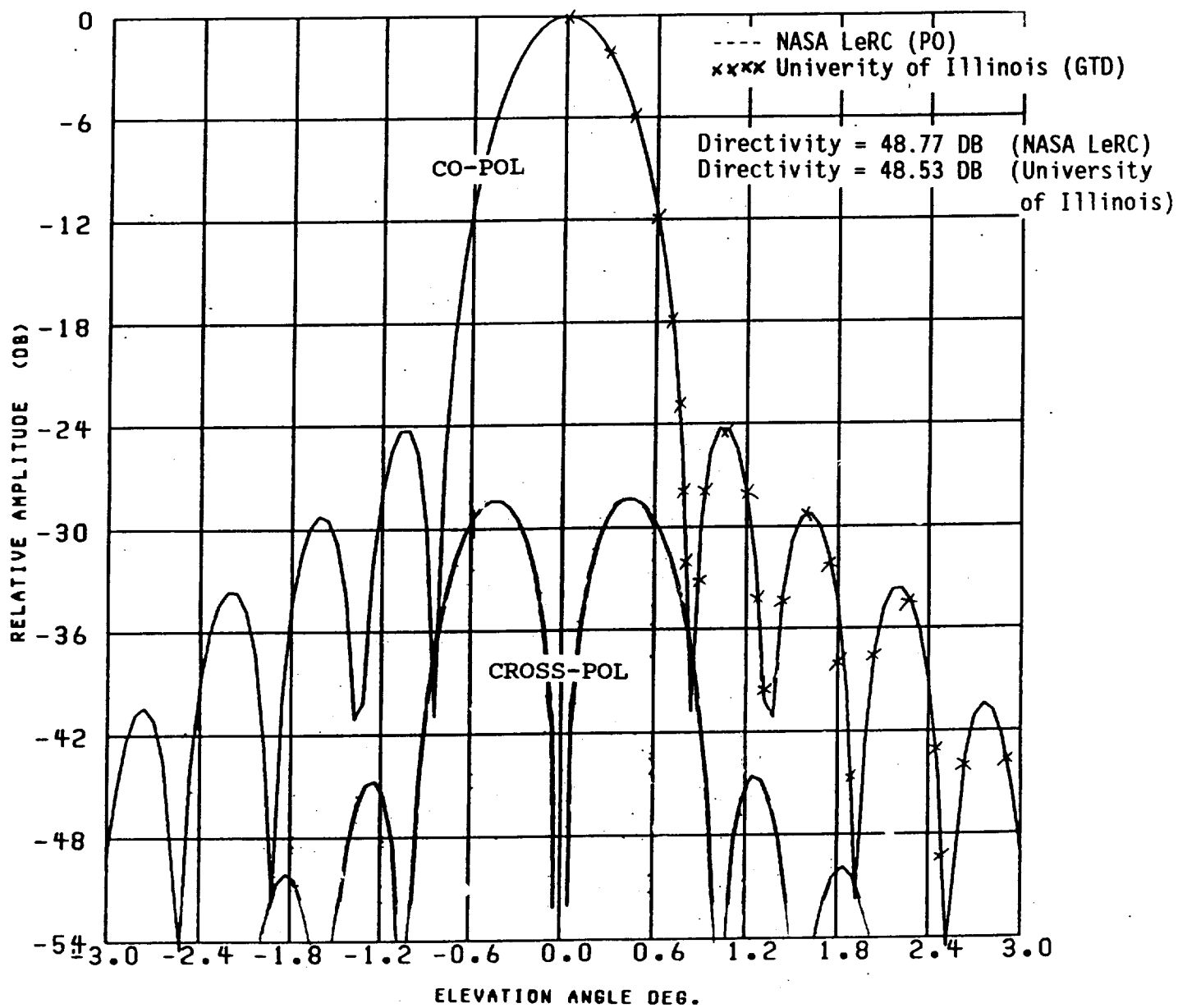


Figure 4a, H-plane far-field antenna pattern

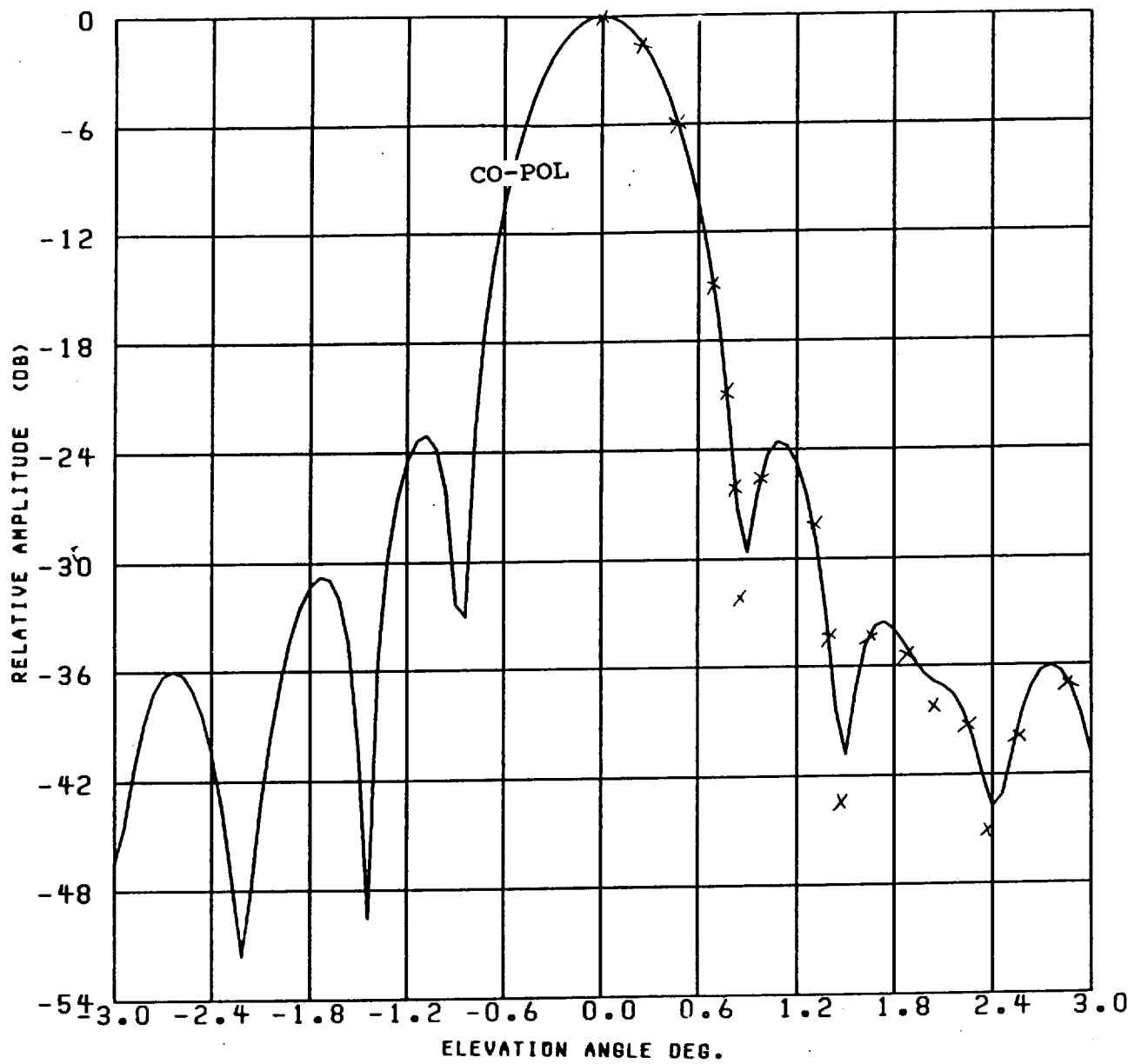


Figure 4b, E-plane far-field antenna pattern

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13. ABSTRACT (Maximum 200 words) Reflector antennas are widely used in communication satellite systems because they provide high gain at low cost. Offset-fed single paraboloids and dual reflector offset Cassegrain and Gregorian antennas with multiple focal region feeds provide a simple, blockage-free means of forming multiple, shaped and isolated beams with low sidelobes. Such antennas are applicable to communications satellite frequency reuse systems and earth stations requiring access to several satellites. While the single offset paraboloid has been the most extensively used configuration for the satellite multiple-beam antenna, the trend toward large apertures requiring minimum scanned beam degradation over the field of view 18 degrees for full earth coverage from geostationary orbit may lead to impractically long focal length and large feed arrays. Dual reflector antennas offer packaging advantages and more degrees of design freedom to improve beam scanning and cross-polarization properties. The Cassegrain and Gregorian antennas are the most commonly used dual reflector antennas. A computer program for calculating the secondary pattern and directivity of a generalized dual reflector antenna system has been developed and implemented at the NASA Lewis Research Center. The theoretical foundation for this program is based on the use of physical optics methodology for describing the induced currents on the sub-reflector and main reflector. The resulting induced currents on the main reflector are integrated to obtain the antenna far-zone electric fields. The computer program is verified with other physical optics programs and with measured antenna patterns. The comparison shows good agreement in far-field sidelobe reproduction and directivity.				
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